3.RESULTS AND DISCUSSION

Results and discussion of the thesis includes two main parts:

a. 1st part is concerned with the concentration levels of the physicochemical parameters of the ground water in the 4-stations in area under investigations for the four seasons during the period from March 2003 to Feb. 2004. It also contains the data of the traditional treatment of these samples.

b. The 2nd part involves the characterization of the activated carbon derived from rice husk and prepared by chemical activation using H_3PO_4. Also, it includes the data for treatment of iron and manganese ground water in station 1 (winter season) using this carbon by the adsorption technique. The aim was to find out an available, local and low cost material to reach the permissible levels using easy techniques to be applied. This replacement technology may be upgraded to achieve complete removal of hardness, as well as iron and manganese, so, it can be used as filters in thousands of homes in the sparsely populated countryside. Thus, treated water quality remained good and no significant harm was caused to the residents.

3.A. 1st section

3.A.1. Physical parameters:-

3.A.1.1. Electrical conductivity

Electrical conductivity (EC) is the measurement of the capacity of water to carry an electric current, it will vary according to the amount of ionized substances in water [92].

This test is not routine in potable water treatment, but when performed on source water is a good indicator of contamination by inorganic substances [92].

The seasonal variations of electrical conductivity at different selected stations of the area under investigation are presented in table (8) and graphically represented in figure (11).The range was found to be 700-1305, 800-1510, 750-1380, 732-1387 and 750-1331, 770-1510, 657-1420, 633-1276 µ mohs/cm before and after traditional treatment during spring, summer , autumn and winter seasons respectively .

The results of EC showed that the highest value is at station IV 1510 µ mohs/cm and the lowest values at station I reached 633 µ mohs/cm.

The high values of EC at station IV may be due to the increase of dissolved solids and contamination of water with chemical reagents used in traditional treatment .

The correlation coefficients of EC with TDS, Cl^-, HCO_3^-, SiO_2, SO_4^{2-} and Ca^{2+} were found to be strong during all seasons. For example Cl^- with EC (r = 1.0, 1.0, 1.0, 1.0) during summer, autumn, spring and winter seasons respectively. The negative correlations were represented with pH, Pb^{2+} and Zn^{2+}. For example Pb^{2+} with EC (r = -0.6, -0.6, -0.6, -0.5) during summer, autumn, spring and winter seasons respectively as shown in tables (36-39).

Table (8): Seasonal variations of electrical conductivity (µ mohs/cm) at selected stations in the studied area before and after traditional treatment during(2003-2004)

Seasons / Stations		Spring	Summer	Autumn	Winter	Annual average	Standard deviation
I	I	700.00	800.00	866.00	804.00	792.50	68.67
	I'	754.00	770.00	716.00	633.00	718.25	61.18
II	II	881.00	960.00	793.00	905.00	884.75	69.53
	II'	873.00	920.00	810.00	815.00	854.50	52.20
III	III	800.00	990.00	750.00	732.00	818.00	118.22
	III'	750.00	800.00	657.00	722.00	732.25	59.65
IV	IV	1305.00	1510.00	1380.00	1387.00	1395.50	84.88
	IV'	1331.00	1510.00	1420.00	1376.00	1409.25	76.36

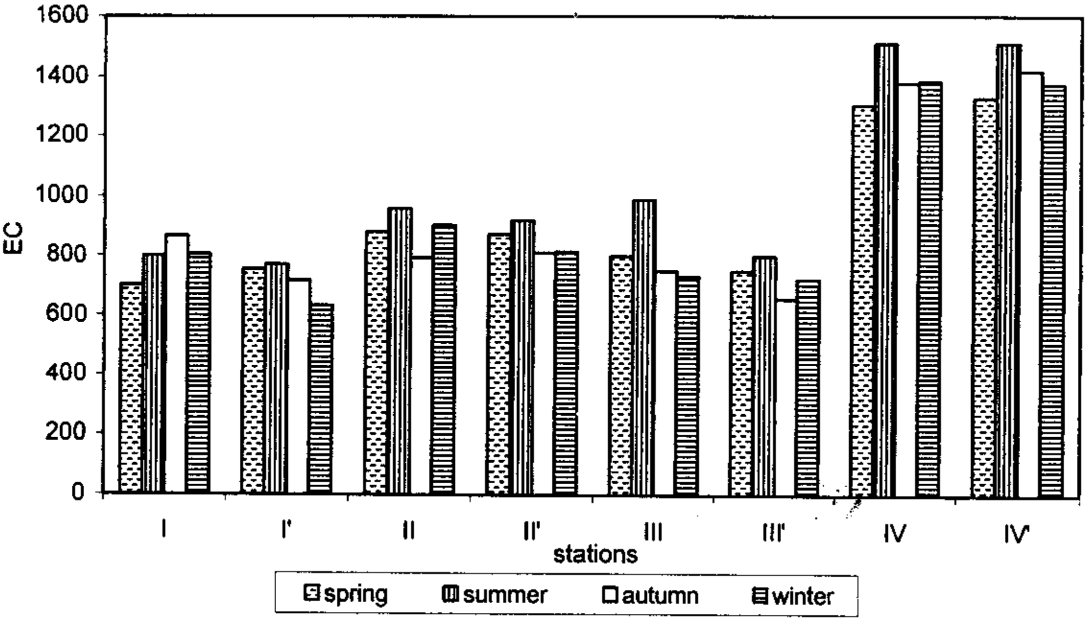


Figure (11): Seasonal variations of electrical conductivity (µ mohs/cm) at selected stations in the studied area before and after traditionai treatment during(2003 - 2004)

The correlation coefficients of EC with COD, Cl^-, NO_2^-, NO_3^-, Fe^{2+}, Mn^{2+} and Pb^{2+} were found to have strong correlations during all stations. For example Cl^- with EC (r = 0.5, 0.2, 0.1, 0.1) during station I, II, III and IV respectively. The negative correlations were represented with pH, CO_3^- and Zn^{2+}. For example pH with EC (r = -0.2, -0.7, -0.8, -0.9) during station I, II, III and IV respectively as shown in tables (40-43).

Water with relatively high Electrical Conductivity causes corrosion to well casing and strainer due to higher Electro-chemical action. Electrical Conductivity of different minerals is not the same. Multiplication of specific conductance values with 0.55-0.75 will give a good estimate of dissolved solids [94].

There is no guideline of EC in WHO but it is correlated with TDS [92 -93].

3.A.1.2. Total solids (TS)

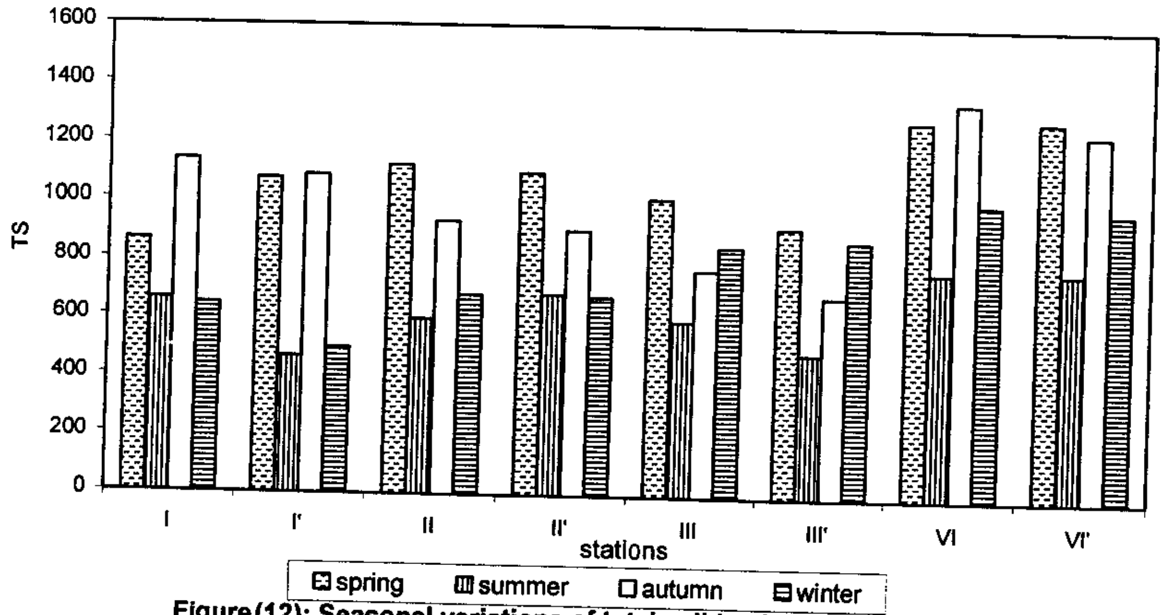
Solids in water are defined as any matter that remains upon evaporation and drying at 105 °C [92].

The seasonal variations of total solids at different selected stations of the area under investigation are presented in table (9) and graphically represented in figure (12). The range was found to be 864 -1381, 996-1350 , 991-1714 , 951-1524 and 920-1357, 854 -1297 , 948-1607, 872-1454 mg/l before and after traditional treatment during spring, summer , autumn and winter seasons respectively .

The results of TS showed that the highest values are at station IV' in autumn season which is 1714 mg/l and lowest values at station I which reach 854 mg/l in summer season.

Table (9): Seasonal variations of total solids (mg/l) at selected stations in the studied area before and after traditional treatment during (2003-2004)

Seasons Stations		Spring	Summer	Autumn	Winter	Annual average	Standard deviation
I	I	864	660	1136	644	826	229.65
	I'	1072	464	1084	496	779	345.54
II	II	1120	596	932	680	832	239.27
	II'	1096	684	904	676	840	200.72
III	III	1012	596	772	854	808.5	173.18
	III'	920	490	684	876	742.5	197.07
IV	IV	1284	772	1348	1004	1102	265.92
	IV'	1288	776	1244	980	1072	239.67



Figure(12): Seasonal variations of total solids (mg /l) at selected stations in the studied area before and after traditional treatment during (2003 - 2004)

The correlation coefficients of TS with TDS, TSS, EC, HCO_3^-, Cl^-, SO_4^{2-}, Mg^{2+} and P as found to be strong correlations during all seasons. For example TDS with TS (r = 0.4, 1.0, 1.0 ,0.9) during summer, autumn, spring and winter seasons respectively. The negative correlations were represented with pH , Pb^{2+} and Zn^{2+}. For example Pb^{2-} with TS (r = -0.2, -0.5,-0.8,-0.6) during summer, autumn, spring and winter seasons respectively as shown in tables (36-39).

The correlation coefficients of TS with TDS, TSS, HCO_3^-, Cl^-, Ca^{2+} and SiO_2 as found to have strong correlations during all stations. For example TDS with TS (r = 0.8, 0.6, 0.3, 0.9) during station I, II, III and IV respectively. The negative correlations as represented with CO_3^{2-}. For example CO_3^{2-} with TS (r = -0.4, -0.8, -0.4, -0.4) during station I, II, III and IV respectively as shown in tables (40-43).

The maximum level of total solids according to WHO is 1500 mg/l. The stations under investigation, except IV, are within normal limits.

3.A.1.3. Total dissolved solids (TDS)

TDS comprise inorganic salts (principally calcium, magnesium, potassium, and sodium cation and, bicarbonates, chlorides and sulfates carbonate and nitrate anions) and small amounts of organic matter that are dissolved in water [92].

The seasonal variations of total dissolved solids at different selected stations of the area under investigation are presented in table (10) and graphically represented in figure (13). The range was found to be 796-1245, 840-1282, 971-1534, 852-1456 and 856-1317, 814-1269, 884-1575, 829-1380 mg/l before and after traditional treatment during spring, summer , autumn and winter seasons respectively .

Table (10): Seasonal variations of total dissolved solids (mg/l) at selected stations in the studied area before and after traditional treatment during (2003-2004)

Seasons Stations		Spring	Summer	Autumn	Winter	Annual average	Standard deviation
I	I	806	480	1116	612	753.5	276.28
	I'	1010	424	1040	460	733.5	337.14
II	II	1032	500	856	604	748	241.22
	II'	1056	508	836	632	758	240.32
III	III	988	456	700	532	669	235.84
	III'	902	408	620	512	610.5	212.74
IV	IV	1148	704	1068	936	964	194.13
	IV'	1248	748	1212	906	1028.5	241.89

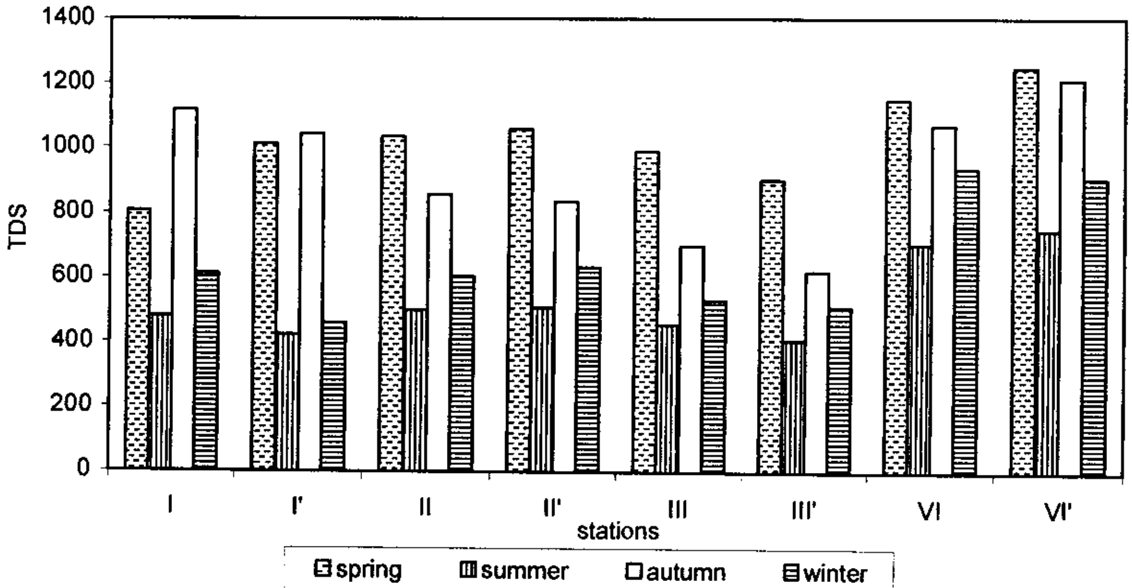


Figure (13): Seasonal variations of total dissolved solids (mg/l) at selected stations in the studied area before and after traditional treatment during(2003 - 2004)

The results of TDS revealed that, the highest values were recorded at station IV and reached 1575 mg/l, while the lowest values were recorded at station III' 829 mg/l during winter season.

The increase in the concentration of TDS at station IV may be due to the high solubility of minerals in ground water at this area.

The previous study in greater Cairo showed that TDS concentration ranged between (1060-1330 mg/l) [98].

TDS in drinking water originate from natural sources, sewage, urban runoff and industrial wastewater hence varied considerably in different geological regions owing to differences in the solubility of minerals [94].

The correlation coefficients of TDS with EC, Cl^-, HCO_3^-, SO_4^{2-}, K^+, Ca^{2+}, Mg^{2+}, P and TP were found to have positive correlations during all seasons. For example HCO_3^- with TDS (r = 1.0,1.0,1.0,1.0) during summer, autumn, spring and winter seasons respectively. The negative correlations were represented with pH, Pb^{2+} and Zn^{2+}. For example Zn^{2+} with TDS (r = -0.5,-0.2,-0.7,-0.6) during summer, autumn, spring and winter seasons respectively as shown in tables (36-39).

The correlation coefficients of TDS with TS, HCO_3^-, Ca^{2+}, TP were found to be strong correlations during all stations. For example Ca^{2+} with TDS (r = 0.9, 0.9, 0.1, 0.9) during station I, II, III and IV respectively as shown in tables (40-43).

According to WHO the high levels of TDS in drinking water (greater than 1200 mg/l) may be objectionable to consumers. Water with extremely low concentrations of TDS may also be unacceptable because of taste. On the other side the Egyptian Authorities set a guideline value of 1200 mg/l for TDS in water supplies [18].

3.A.1.4. Total suspended solids (TSS)

According to (APHA, 1995) suspended solids is the portion of solids that retained on the filter paper after filtration of water by 0.2 mm or smaller nominal pore size under specified conditions [92].

The seasonal variations of total suspended solids at different selected stations of the area under investigation are presented in table (11) and graphically represented in figure (14).The range was found to be 24-136 , 68-180 , 20-180 , 32-76 and 18-62, 28-176, 32-68, 36-74 mg/l before and after traditional treatment during spring, summer , autumn and winter seasons respectively.

The results of TSS indicated that, the highest values was recorded at station IV in summer which reach 180 mg/l, while the lowest value was at station I 20 mg/l in autumn season.

The higher concentration of TSS at station IV may be due to the presence of suspended and organic material or pollution from surface water and rains .

The correlation coefficients of TSS with Cl^-, HCO_3^-, Na^- and K^- were found to have positive correlations during all seasons except the summer season. For example K^+ with TSS (r = -0.4, 0.4, 0.5, 0.6) during summer, autumn, spring and winter seasons respectively. The negative correlations a represented with pH and NO_2^- as shown in tables (36-39).

The correlation coefficients of TSS with TS, SiO_2, P, Fe^{2-} and Pb^{2+} were found to be strong correlations during all stations. For example Fe^{2+} with TSS (r = 0.1, 0.8, 0.2, 0.6) during station I, II, III and IV respectively. The negative correlations were represented with Na^-. For example Na^+ with TSS (r = 0.0, -0.1, -0.6, -0.4) during station I, II, III and IV respectively as shown in tables (40-43).

Table (11): Seasonal variations of total suspended solids (mg/l) at selected stations in the studied area before and after traditional treatment during (2003-2004)

Seasons / Stations		Spring	Summer	Autumn	Winter	Annual average	Standard deviation
I	I	58	180	20	32	58.2	63.89
	I'	62	40	64	36	50.5	12.60
II	II	88	96	76	76	84	8.49
	II'	40	176	68	44	82	55.32
III	III	24	140	72	52	72	42.80
	III'	18	82	64	64	57	23.69
IV	IV	136	68	180	68	113	47.61
	IV'	40	28	32	74	43.5	18.13

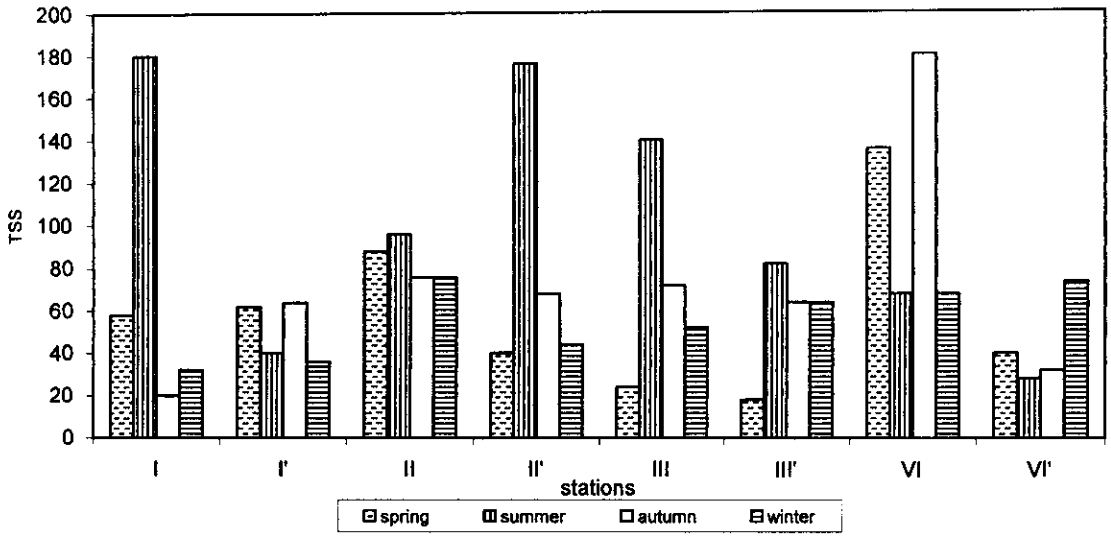


Figure (14): Seasonal variations of total suspended dissolved solids (mg/l) at selected stations in the studied area before and after traditional treatment during (2003 - 2004)

Water filtration has long been an important technique in removing the suspended solids. The Egyptian standards for turbidity in drinking water are 5 NTU for surface water and 1 NTU underground sources [18].

3.A.2. Chemical parameters:-

3.A.2.1 "pH"

pH is defined as the negative logarthim of hydrogen ion concentration of solution. This is a measure of the ionized hydrogen in solution [92].

The seasonal variations of hydrogen ion concentration at different selected stations of the area under investigation are presented in table (12) and graphically represented in figure (15). The pH range was found to be 8.09-8.3, 7.32-7.41, 7.66-7.85, 7.8-7.84 and 8.06-8.26, 7.25-7.86, 7.64-8.27, 7.77-8.3 before and after traditional treatment during spring, summer, autumn and winter seasons respectively.

The present data of pH showed that the highest values were recorded at station III' which reached 8.3 during winter season. But the lowest values of pH reached 7.25 at station I in autumn season.

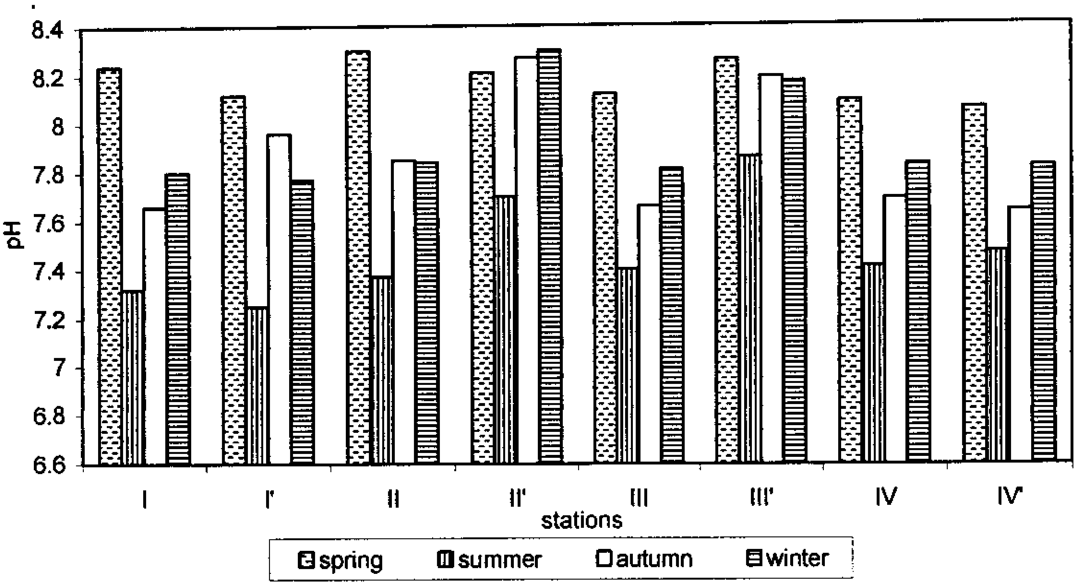
The high values of pH at station III may be due to presence of dissolved carbonate and bicarbonate.

The chemical and physical properties and reactivity of almost every component in water depend upon pH, it relates to corrostivity, contaminant solubility and conductivity of water [92].

The correlation coefficients of pH with P and COD were found to have positive correlations during all seasons. For example Pb^{2+} with pH (r = 0.5, 0.3, 1.0, 0.7) during summer, autumn, spring and winter seasons respectively. The negative correlations were represented with HCO_3^- , Cl^-, K^+, Ca^{2+} and (Fe^{2+} and Mn^{2+} except for the winter season). For example

Table (12): Seasonal variations of pH (mg/l) at selected stations in the studied area before and after traditional treatment during (2003-2004)

Seasons / Stations		Spring	Summer	Autumn	Winter	Annual average	Standard deviation
I	I	8.24	7.32	7.66	7.80	7.76	0.38
	I'	8.12	7.25	7.96	7.77	7.78	0.38
II	II	8.30	7.37	7.85	7.84	7.84	0.38
	II'	8.21	7.70	8.27	8.30	8.12	0.28
III	III	8.12	7.40	7.66	7.81	7.75	0.30
	III'	8.26	7.86	8.19	8.17	8.12	0.18
IV	IV	8.09	7.41	7.69	7.83	7.76	0.28
	IV'	8.06	7.47	7.64	7.82	7.75	0.25



Figure(15): Seasonal variations of pH(mg /l) at selected stations in the studied area before and after traditional treatment during (2003 - 2004)

Pb^{2+} with Ca^{2+} (r = -0.4, -0.3, -0.6, -1.0) during summer, autumn, spring and winter seasons respectively as shown in tables (36-39).

The correlation coefficients of pH with CO_3^{2-}, Na^- and K^- were found to have strong correlations during all stations. For example CO_3^{2-} with pH (r = 0.6, 0.4, 0.3, 0.8) during station I, II, III and IV respectively. The negative correlations were represented with EC, COD, Cl^-, Fe^{2-}, Mn^{2-}, Pb^{2+}. For example pH with pH (r= -0.1, -0.1, -0.3, -0.6) during station I, II, III and IV respectively as shown in tables (40-43).

Generally, WHO, Canadian and USA specifications reported that, the pH have level (6.5-8.5) but in Egyptian specification is (6.5-9.2). therefore the ground water of studied area are within normal limits [18].

3.A.2.2. Chemical oxygen demand (COD)

According to (APHA, 1995) the chemical oxygen demand COD is referred to the measure of oxygen equivalent to organic matter content of the samples oxidized by mild oxidizing agent e.g. $KMnO_4$ or $K_2Cr_2O_7$ [93].

The seasonal variations of chemical oxygen demand at different selected stations of the area under investigation are presented in table (13) and graphically represented in figure (16).The range was found to be 0.8-2.4, 2.4-6, 2.4-8, 2.4-4.8 and 1.2-2, 3.2-6.8, 2.4-4.4, 2.8-4 mg/l before and after traditional treatment during spring, summer , autumn and winter seasons respectively.

The data obtained of COD showed that the maximum values reached 8 mg/l at station I and the minimum value 0.8 mg/l at station IV.

The correlation coefficients of COD with TS, TDS, EC, Cl^-, HCO_3^-, SiO_2, SO_4^{2-} and Ca^{2+} were found to have positive correlations during all seasons except spring season. For example TDS with COD (r = 0.2, 0.1, -0.8, 0.8) during summer, autumn, spring and winter seasons respectively. as shown in tables (36-39).

Table (13): Seasonal variations of chemical oxygen demand (mg/l) at selected stations in the studied area before and after traditional treatment during (2003-2004)

Seasons / Stations		Spring	Summer	Autumn	Winter	Annual average	Standard deviation
I	I	2.00	2.40	8.00	2.80	3.80	2.82
	I'	2.00	3.20	4.00	2.80	3.00	0.83
II	II	1.60	5.20	4.00	3.60	3.60	1.50
	II'	1.20	6.80	4.40	4.00	4.10	2.29
III	III	2.40	6.00	2.40	2.40	3.30	1.80
	III'	2.00	6.40	2.40	2.80	3.40	2.03
IV	IV	0.80	4.80	2.40	4.80	3.20	1.96
	IV'	1.20	5.60	4.40	4.00	3.80	1.86

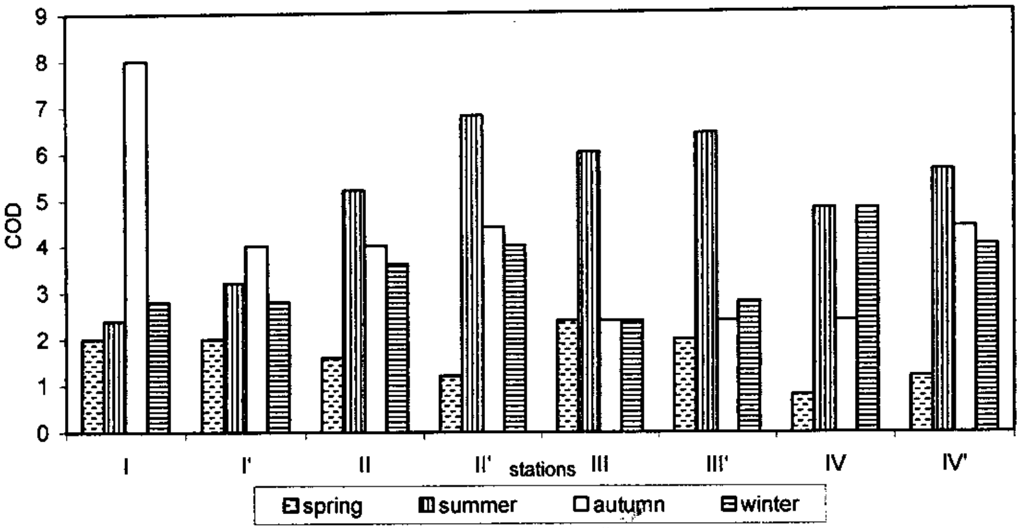


Figure (16): Seasonal variations of chemical oxygen demand (mg/l) at selected stations In the studied area before and after traditional treatment during (2003 - 2004)

The correlation coefficients of COD with EC, SiO_2 were found to have strong correlations during all stations. For example EC with COD (r = 0.6, 0.3, 0.7, 0.7) during station I, II, III and IV respectively. The negative correlations were represented with pH, CO_3^{2-}. For example pH with COD (r= -0.2, -0.5, -0.5, -0.8) during station I, II, III and IV respectively as shown in tables (40-43).

The lower values of COD were recorded at all stations during different seasons, probably due to very small quantity of organic matter in the ground water of this area .

3.A.2.3. Major Anions:-

(i) Alkalinity:-

Alkalinity is defined as the ability of water to resist a change in pH when an acid is added; It relates to the pH buffering capacity of the water. Almost all natural water have some alkalinity. This is thenature means of keeping the pH neutral and stable so that life can exist there. There are three major ions that contribute to total alkalinity CO_3^{2-}, HCO_3^-,and OH^- alkalinity of drinking water is not considered as hazard to health [92].

(a) Carbonate alkalinity

Seasonal variations of carbonate contents at different selected stations of the area under investigation are presented in table (14) and graphically represented in figure (17). The range was found to be 10-15 , 5-10 mg/l before and after traditional treatment respectively during spring season and not detected during summer, autumn and winter seasons.

The present results indicated. that the carbonate contents only represent during spring, this may be due to the flourishing of microorganism in ground water during this season [95].

Table (14): Seasonal variations of carbonate (mg/l) at selected stations in the studied area before and after traditional treatment during (2003-2004)

Seasons / Stations		Spring	Summer	Autumn	Winter	Annual average	Standard Deviation
I	I	15.00	N.D.	N.D.	N.D.	3.75	7.50
	I'	5.00	N.D.	N.D.	N.D.	1.25	2.50
II	II	15.00	N.D.	N.D.	N.D.	3.75	7.50
	II'	10.00	N.D.	10.00	N.D.	5.00	5.77
III	III	10.00	N.D.	N.D.	N.D.	2.50	5.00
	III'	10.00	N.D.	10.00	N.D.	5.00	5.77
IV	IV	10.00	N.D.	N.D.	N.D.	2.50	5.00
	IV'	10.00	N.D.	N.D.	N.D.	2.50	5.00

N.D.: Not detected

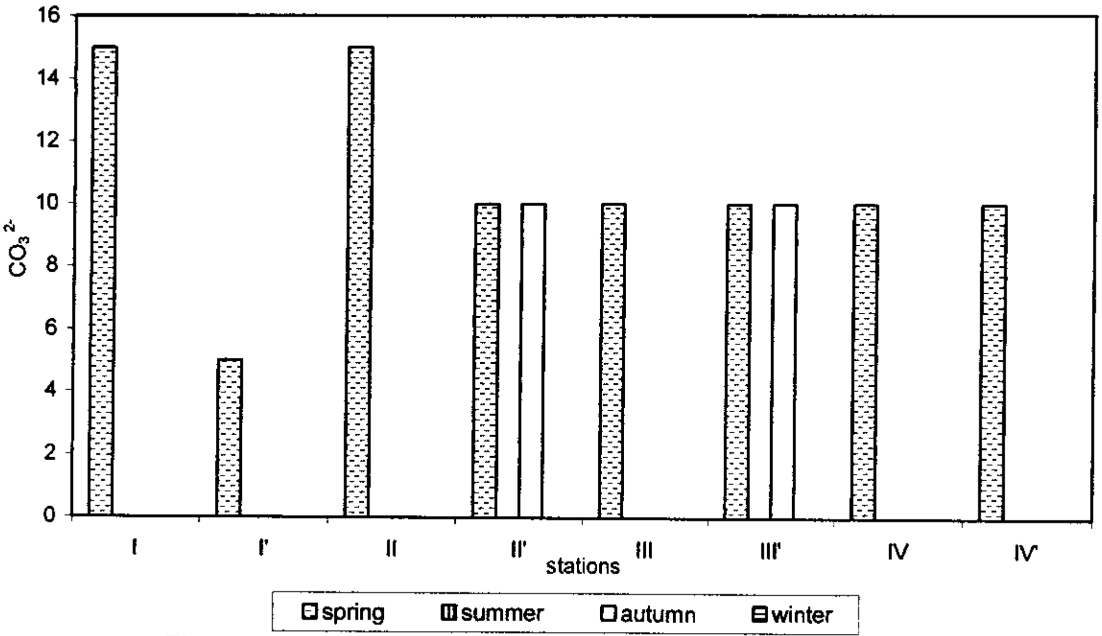


Figure (17): Seasonal variations of carbonate (mg /l) at selected stations in the studied area before and after traditioal treatment during (2003 - 2004)

The previous study in great Cairo as showed that $CO_3{}^{2-}$ concentration 0 mg/l [98].

The correlation coefficients of CO_3^{2-} with Fe^{2-} , P, Pb^{2-} and Na^{+} were found to have positive values during all seasons. For example Fe^{2+} with CO_3^{2-} (r= 0.6) during spring season only. The negative correlations were represented with HCO_3^-, SO_4^{2-} and Zn^{2+}. For example Zn^{2-} with $CO_3{}^{2-}$ (r = -0.3) during spring season only as shown in tables (36-39).

The correlation coefficients of CO_3^{2-} with pH, Na^{+}, Mg^{2-} and NH_3 were found to be strong correlations during all stations. For example pH with CO_3^{2-} (r= 0.5, 0.4, 0.3, 0.8) during station I, II, III and IV respectively. The negative correlations were represented with TS, COD, HCO_3^-, Cl^-, K^+, NO_3^-, P, Zn^{2+}. For example P with CO_3^{2-} (r = -0.8, -0.7, -0.7, -0.2) during station I, II, III and IV respectively as shown in tables (40-43).

Finally the amount of carbonate alkalinity in water will depend up on the chemical component of the geologic strata upon which the body water rests, and their solubility of various pHs [97].

(b) Bicarbonate alkalinity

Bicarbonate has originated from carbonate that have dissolved from underlying rock and have already reacted with acids ,forming the bicarbonate. In pure water , bicarbonate has only slight capacity to raise the pH, bicarbonate changes one molecule of strong acid to a molecule of weak reversible acid :

$NaHCO_3 + HCl \leftrightarrow H_2CO_3 + NaCl$ [92]........................(3.1)

The bicarbonate ions in the water have two important functions, the first one provides the main buffer system for resulting the pH of water, while the second provides the carbon dioxide necessary for the photosynthetic process of phytoplankton . For this reason, photosynthesis has an influence on raising the pH and formation of CO_3^{2-} in the presence of light, the process being reversed in the dark [95].

Seasonal variations of bicarbonate alkalinity at different selected stations of the area under investigation are presented in table (15) and graphically represented in figure(18).The fluctuations of HCO_3^- found to be 453.6-696.6, 486-664.2, 527-770, 526.5-729 and 453.6-737.1, 478-648, 494-794, 486-721 mg/l before and after traditional treatment during spring, summer , autumn and winter seasons respectively .

The maximum values of HCO_3^- recorded 794 mg/l at station IV' and the minimum of 453.6 mg/l at station II during winter and spring seasons respectively.

The high values of HCO_3^- were noticeable at all stations of the area under investigation. This may be attributed to dissolution of CO_2 & CO_3 and formation of HCO_3^- according to the following equation:-

$$CO_2 + CO_3^- + H_2O \leftrightarrow 2HCO_3^- \quad ....(3.2)$$

The previous study in greater Cairo showed that HCO_3^- concentration was between 500 and 583 mg/l [98].

The correlation coefficients of HCO_3^- with TS, TDS, EC, Cl^- ,SO_4^{2-} , Na^+ , K^+,Ca^{2+}, Mg^{2+}, P and TP were found to have positive correlation during all seasons. For example TDS with HCO_3^- (r = 1.0, 1.0, 1.0, 1.0) during summer, autumn, spring and winter seasons respectively. The negative correlations were represented with pH, and Pb. For example pH with HCO_3^- (r = -0.3, -0.5, -0.8, -0.4) during summer, autumn, spring and winter seasons respectively as shown in tables (36-39).

The correlation coefficients of HCO_3^- with TS, TDS, Cl^-, Ca^{2+} and TP were found to be strong correlation during all stations. For example TS with HCO_3^- (r = 0.2, 0.7, 0.5, 0.8) during station I, II, III and IV respectively. The negative correlations were represented with pH, CO_3^{2-}

Table (15): Seasonal variations of bicarbonate (mg/l) at selected stations in the studied area before and after traditional treatment during (2003-2004)

Seasons / Stations		Spring	Summer	Autumn	Winter	Annual average	Standard deviation
I	I	461.70	486.00	551.00	535.00	508.43	41.65
	I'	469.80	486.00	527.00	518.40	500.30	26.93
II	II	453.60	478.00	527.00	526.60	496.30	36.60
	II'	453.60	478.00	494.10	486.00	477.93	17.50
III	III	558.90	543.00	567.00	526.50	548.85	17.93
	III'	494.10	478.00	494.10	510.30	494.13	13.19
IV	IV	696.60	664.20	770.00	729.00	714.95	45.24
	IV'	737.10	648.00	794.00	721.00	725.03	60.15

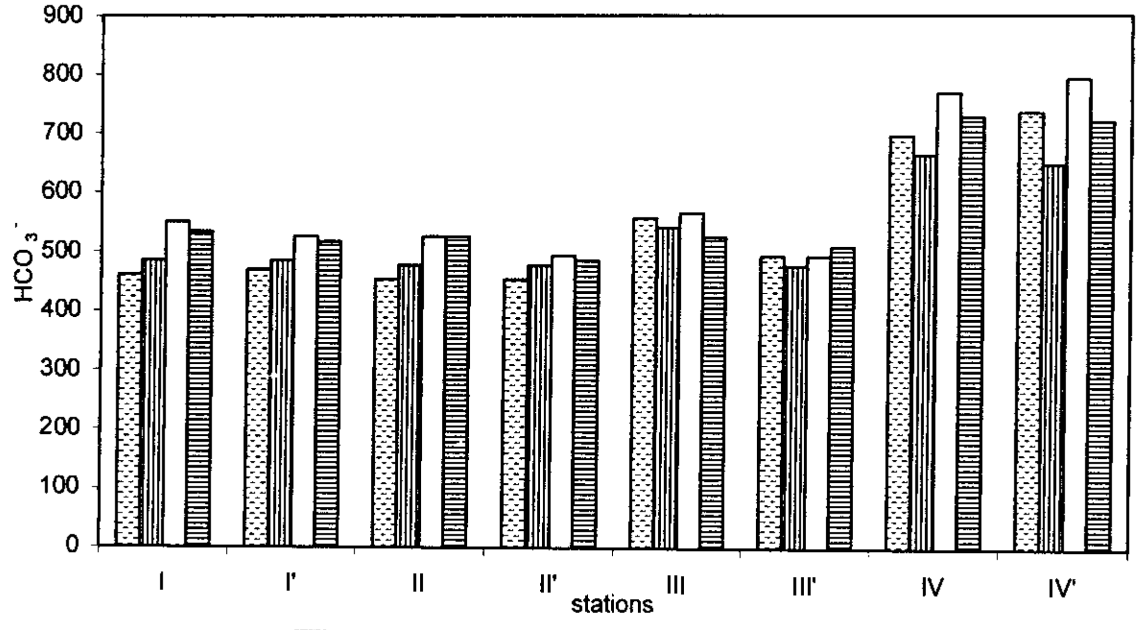


Figure (18): Seasonal variations of bicarbonate (mg/l) at selected stations in the studied area before and after traditional treatment during (2003 - 2004) and NO_2^-. For example NO_2^- with HCO_3^- (r = -0.2, -0.5, -0.5, -0.7) during station I, II, III and IV respectively as shown in tables (40-43).

Finally, phosphate and borate and others are also sources of alkalinity, but the concentration of these in clear water is so small that their effect are insignificant [92].

ii) Sulphate

Sulphate is one of the major anion, occurring in natural waters .it is importance in public water supplies because of its cathartic effect upon some humans when present in excessive amounts [92].

Seasonal variations of Sulphate at different selected stations of the area under investigation are presented in table (16) and graphically represented in figure (19).The range was found to be 39.12-107.21, 43.21-113.77, 40.61-134.7, 51.25-139 and 54.42-112.16, 35.16-117.86, 46.97-135, 43-136.55 mg/l before and after traditional treatment during spring, summer , autumn and winter seasons respectively .

Also, the maximum value of SO_4^{2-} was recorded at station VI 139 mg/l and the minimum of 39.12 mg/l at station I during winter and spring seasons respectively.

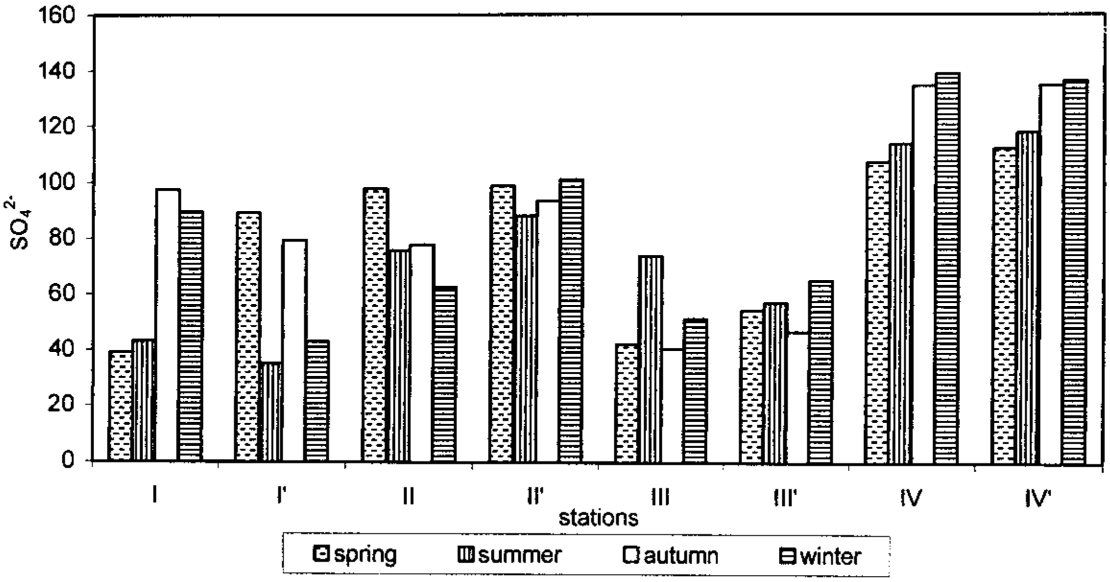
The concentrations of the present SO_4^{2-} values (groundwater) are high than surface water which ranged between (16.22 and 64.6 mg/l) Abdo, (2002). Also, the comparison with other groundwater studies in great Cairo showed that SO_4^{2-} concentration ranged between (67 -384 mg/l) [94].

Generally the relative increase of SO_4^{2-} found in groundwater samples may be explained due to dissolution of sulphate salts constituent in some ground rocks of the area under investigation.

The correlation coefficients of SO_4^{2-} with TS, TDS, EC, Cl^- ,SO_4^{2-} , Na^+ , K^+ ,Ca^{2+}, Mg^{2-}, P and TP were found to have positive correlations during all seasons. For example TS with SO_4^{2-} (r = 0.4, 0.8, 0.6, 0.8) during

Table (16): Seasonal variations of sulfate (mg/l) at selected stations in the studied area before and after traditional treatment during (2003-2004)

Seasons / Stations		Spring	Summer	Autumn	Winter	Annual average	Standard deviation
I	I	39.12	43.21	97.43	89.52	67.32	30.42
	I'	89.26	35.16	79.36	43.00	61.70	26.62
II	II	97.80	75.65	77.75	62.52	78.43	14.57
	II'	98.80	88.15	93.47	101.02	95.36	5.76
III	III	42.20	73.70	40.61	51.25	51.94	15.24
	III'	54.23	57.07	46.67	65.00	55.74	7.57
IV	IV	107.21	113.77	134.70	139.00	123.67	15.55
	IV'	112.16	117.86	135.00	136.55	125.39	12.23



Figure(19): Seasonal variations of sulfate (mg/l) at selected stations in the studied area before and after traditional treatment during (2003 - 2004) summer, autumn, spring and winter seasons respectively. The negative correlations were found with Pb^{2+} and Zn^{2-}. For example Zn^{2+} with SO_4^{2-} (r = -0.6, -0.1, -1.0, -0.9) during summer, autumn, spring and winter seasons respectively is shown in tables (39-39).

The negative correlation were represented with CO_3^{2-} and Mg^{-2}. For example Mg^{2+} with SO_4^{2-} (r = -0.5, -0.7, -0.9, -0.1) during station I, II, III and IV respectively as shown in tables (40-43).

Finally, Sulphate have maximum contaminant level 400 mg/l in WHO specification, and Egyptian specification.

(iii) Chlorosity

Chlorides occur in all natural water in varying concentration. Concentration is usually greater in ground water than surface water, especially if salt deposits are in the area [92].

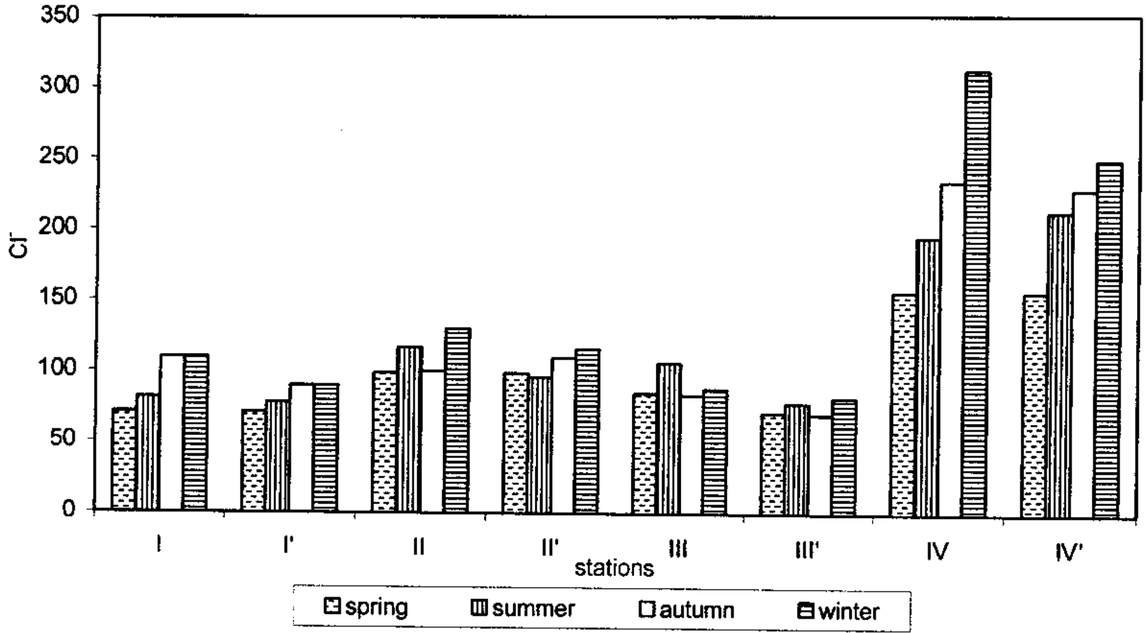
Chlorides in small concentrations are not harmful to human in drinking water and with some adaptation the human body can tolerate a water with as much as 2000 mg/l chloride ion. However, above a concentration of 250 mg/l chloride, the water may taste salty, and a secondary MCl has been set at this level for community supplies [92].

Seasonal variations of chloride at different selected stations of the area under investigation are presented in table (17) and graphically represented in figure (20).The range was found to be 71-156, 78-195, 84-234, 88-312 and 71-156, 78-212, 70-228, 82-249 mg/l before and after traditional treatment during spring, summer , autumn and winter seasons respectively.

The present results of chloride show that the highest value at station IV in summer season 312 mg/l and the lowest value is at station III' in autumn season 70 mg/l.

Table (17): Seasonal variations of chloriosity (mg/l) at selected stations in the studied area before and after traditional treatment during (2003-2004)

Seasons / Stations		Spring	Summer	Autumn	Winter	Annual average	Standard deviation
I	I	71.00	81.50	110.00	110.00	93.13	19.95
	I'	71.00	78.00	90.00	90.00	82.25	9.39
II	II	99.00	117.00	100.00	130.00	111.50	14.84
	II'	99.00	96.00	110.00	116.00	105.25	9.36
III	III	85.00	106.30	84.00	88.00	90.83	10.46
	III'	71.00	78.00	70.00	82.00	75.25	5.74
IV	IV	156.00	195.00	234.00	312.00	224.25	66.61
	IV'	156.00	212.70	228.00	249.00	211.43	39.83



Figure(20): Seasonal variations of chloriosity (mg/l) at selected stations in the studied area before and after traditional treatment during (2003 - 2004)

The high values of chloride recorded at station IV may be due to the old buildings of this station and input of some impurities during the treatment system.

The previous study showed that chloride concentration ranged between (103 - 172 mg/l) [98].

The relative increases of chloride concentrations after treatment is due to treatment processes which use chlorine in disinfection and oxidation by using chlorine and hypochlorite.

Generally the high values of chloride concentrations in groundwater source may be due to sewage contamination or industrials waste discharge.

The correlation coefficients of Cl^- with TS, TDS, EC, SO_4^{2-}, Na^+, K^+ Ca^{2+}, Mg^{2+}, TP and P were found to be positive during all seasons. For example P with Cl^- (r = 0.7,0.4,0.8,0.2) during summer, autumn, spring and winter seasons respectively. The negative correlations were represented with pH , TSS, Pb^{2+} and Zn^{2+}. For example pH with Cl^- (r = -0.3, -0.5, -0.6, -0.3) during summer, autumn, spring and winter seasons respectively as shown in tables (36-39)

The correlation coefficients of Cl^- with TS, TDS, TSS, EC, COD, HCO_3^-, P, TP and Fe^{2+} were found to have strong correlation during all stations. For example HCO_3^- with Cl^- (r = 0.9, 0.5, 0.16, 0.3) during station I, II, III and IV respectively. The negative correlations were represented with pH, CO_3^{2-}, Mg^{2+}, NH_3 and Pb^{2+}. For example CO_3^{2-} with Cl^- (r = -0.6, -0.5, -0.2, -0.7) during station I, II, III and IV respectively as shown in tables (40-43).

The permissible limits of chloride at contaminate is a level 600 mg/l in WHO specification, while the Egyptian specification is 500mg/l [18]. Therefore the chloride concentration in ground water of the area under investigation are within normal limits.

3.A.2.4. Major cations:-
(i) Sodium

Sodium ranks as the sixth among the elements in order of abundance [93] . Sodium salts are generally soluble in water and are leached from the terrestrial environment to ground water and surface water .they are non - volatile and will thus be found in the atmosphere only in association with particulate matter [95].

Seasonal variations of sodium at different selected stations of the area under investigation are presented in table (18) and graphically represented in figure (21). The range was found to be 32.5-81.2, 36.26-84.67, 45.85-92.34, 36-86.33 and 32.5-81.2, 35.67-84.67, 43.3-93.62, 32.7-86.33 mg/l before and after traditional treatment during spring, summer , autumn and winter seasons respectively .

The maximum value of Na^+ was recorded at station IV' 93.62 mg/l in autumn season and the minimum of 32.5 mg/l at stations I,I' during autumn and spring seasons respectively.

The relative increase of sodium concentrations at station IV & IV' may be due the input of some impurities and the use of sodium salts in water treatment, including softening, disinfection, pH adjustment and coagulation .

The previous study showed that sodium concentration ranged between (163 - 189 mg/l) [94].

The correlation coefficients of Na^+ with TS, TDS, EC, HCO_3^-, Cl^-, SO_4^{2-}, Na^+ and K^+ were found to have positive correlation during all seasons. For example SO_4^{2-} with Na^+ (r = 0.9, 0.7, 0.8, 1.0) during summer, autumn, spring and winter seasons respectively. The negative correlations were represented with Zn^{2+} and Pb^{2+}. For example Pb^{2+} with Na^+ (r = -0.5, -0.3, 0.0, -0.5) during summer, autumn, spring and winter seasons respectively as shown in tables (37-39).

Table (18): Seasonal variations of sodium (mg/l) at selected stations in the studied area before and after traditional treatment during (2003-2004)

Seasons / Stations		Spring	Summer	Autumn	Winter	Annual average	Standard deviation
I	I	32.50	39.00	45.85	36.00	38.34	5.67
	I'	32.50	35.67	43.30	32.70	36.04	5.05
II	II	51.42	45.18	48.40	54.27	49.82	3.91
	II'	51.42	52.32	51.00	45.63	50.09	3.03
III	III	48.70	36.26	50.30	43.17	44.61	6.35
	III'	51.42	52.80	49.03	47.00	50.06	2.57
IV	IV	81.20	84.67	92.34	86.33	86.14	4.66
	IV'	81.20	84.67	93.62	86.33	86.46	5.23

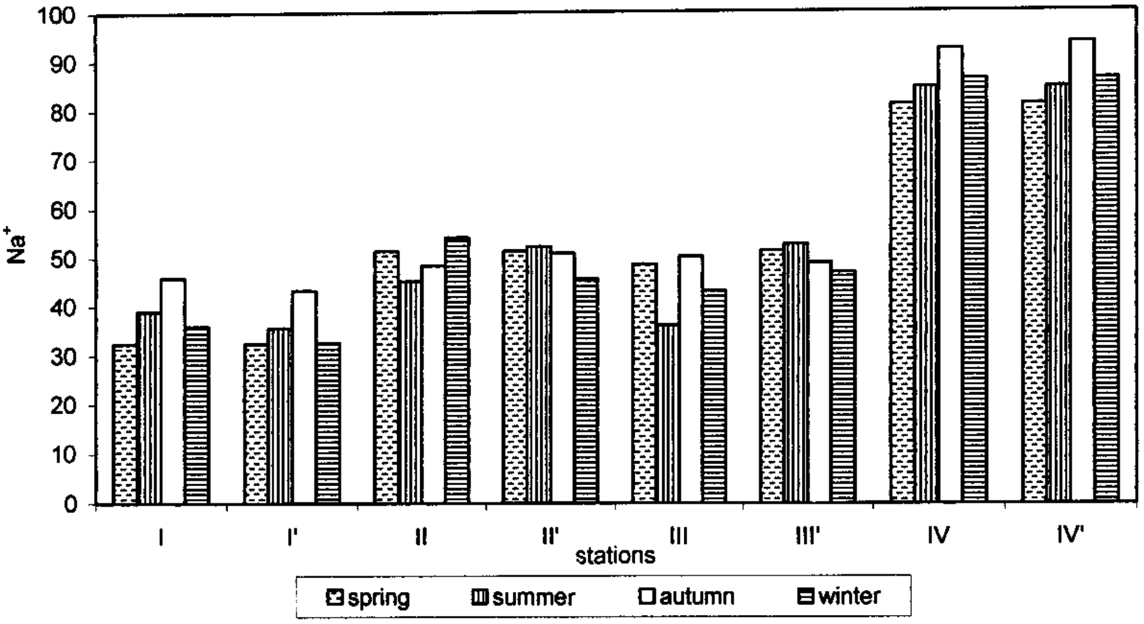


Figure (21): Seasonal variations of sodium (mg/l) at selected stations in the studied area before and after traditional treatment during (2003-2004)

The correlation coefficients of Na^+ with pH and CO_3^{2-} were found to have strong correlation during all stations. For example pH with Na^+ (r = 0.0, 0.8, 0.6, 0.6) during station I, II, III and IV respectively. The negative correlations were represented with TS and P. For example P with Na^+ (r = -1.0, -0.5, -0.6, -0.6) during station I, II, III and IV respectively as shown in tables (40-43).

WHO and Egyptian specifications have the maximum level of Na 200 mg/l in ground water [18]. Therefore, the ground water of the studied area in the permissible limits.

(ii) Potassium

Potassium ranks as the seventh among the elements in order of abundance ,also potassium is rarely consider important for ecology of algae; and this ion apparently always present in smaller amounts than sodium ,the difference tending to increase with salinity [92].

Seasonal variations of potassium at different selected stations of the area under investigation are presented in table (19) and graphically represented in figure (22).The range was found to be 7.25-13.4, 6.51-12.4, 6.05-13, 8.94-17 and 6.75-12.7, 6.51-12.07, 6.37-13, 8.72-17 mg/l before and after traditional treatment during spring, summer , autumn and winter seasons respectively .

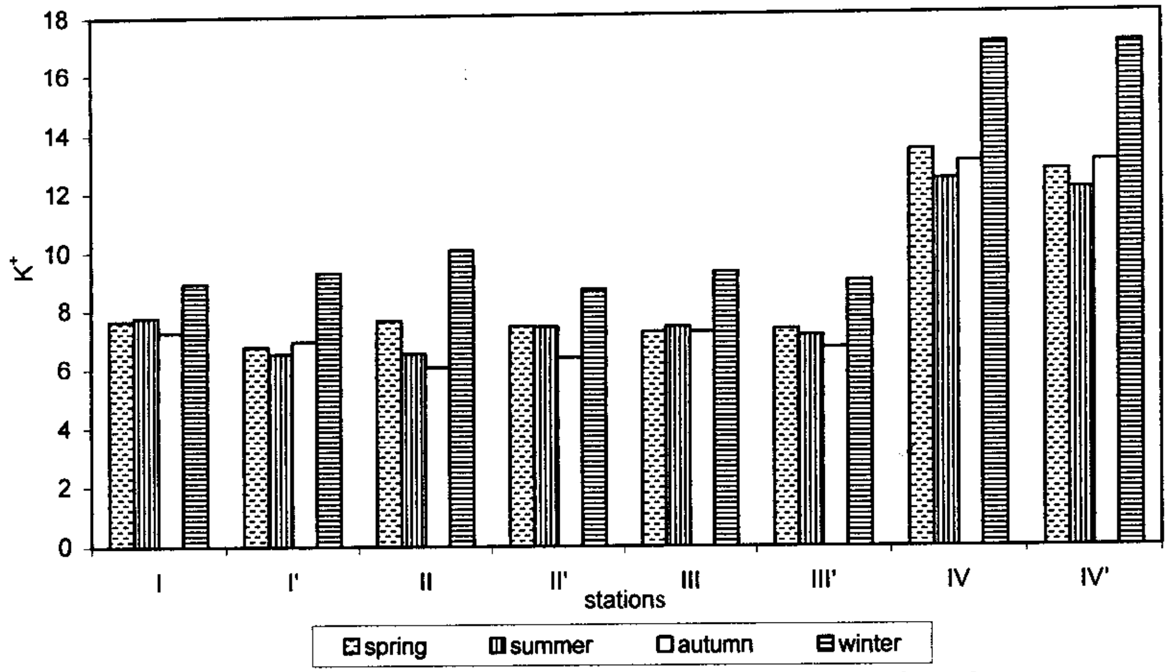
The maximum values of K^+ recorded at station IV (17 mg/l) and the minimum of (6.37 mg/l) at station I' during winter and summer seasons respectively.

The higher values of K^+ were observed at station IV may be related to the input of some impurities due to commercial materials which use in treatment .

The comparison of results between River Nile water ranged between (4 –7 mg/l) (Abdo 2002) [95] while the present ranges of groundwater is

Table (19): Seasonal variations of potassium (mg/l) at selected stations in the studied area before and after traditional treatment during (2003-2004)

Seasons / Stations		Spring	Summer	Autumn	Winter	Annual average	Standard Deviation
I	I	7.65	7.75	7.25	8.94	7.90	0.73
	I'	6.75	6.51	6.92	9.31	7.37	1.30
II	II	7.65	6.51	6.05	10.05	7.57	1.79
	II'	7.45	7.43	6.37	8.72	7.49	0.96
III	III	7.25	7.43	7.25	9.31	7.81	1.00
	III'	7.35	7.13	6.71	9.01	7.55	1.01
IV	IV	13.40	12.40	13.00	17.00	13.95	2.07
	IV'	12.70	12.07	13.00	17.00	13.69	2.24



Figure(22): Seasonal variations of potassium (mg/l) at selected stations in the studied area before and after traditional treatment during (2003 - 2004)

(6.51-17 mg/l) shows that groundwater is relatively higher than surface water in potassium content.

The correlation coefficients of K^- with TS, TDS, EC, Cl^- and SO_4^{2-} were found to have positive correlations during all seasons. For example EC with K^+ ($r = 1.0, 1.0, 1.0, 1.0$) during summer, autumn, spring and winter seasons respectively. The negative correlations were represented with pH, Zn^{2+} and Pb^{2+}. For example pH with K^- ($r = -0.1,-0.6,-0.7,-0.4$) during summer, autumn, spring and winter seasons respectively as shown in tables (36-39).

The correlation coefficients of K^- with pH, HCO_3^- and P were found to have strong correlations during all stations. For example P with K^- (r = 1.0, 0.4, 0.8, 0.19 during station I, II, III and IV respectively. The negative correlations were represented with TSS, CO_3^{2-} and Mg^{2+}, NH_3. For example Mg^{2+} with K^+ ($r = -0.7, -1.0, -1.0, -0.9$) during station I, II, III and IV respectively as shown in tables (40-43).

Also, the comparison with other studies, recorded that, the mean values of K^+ is 4 mg/l [18].

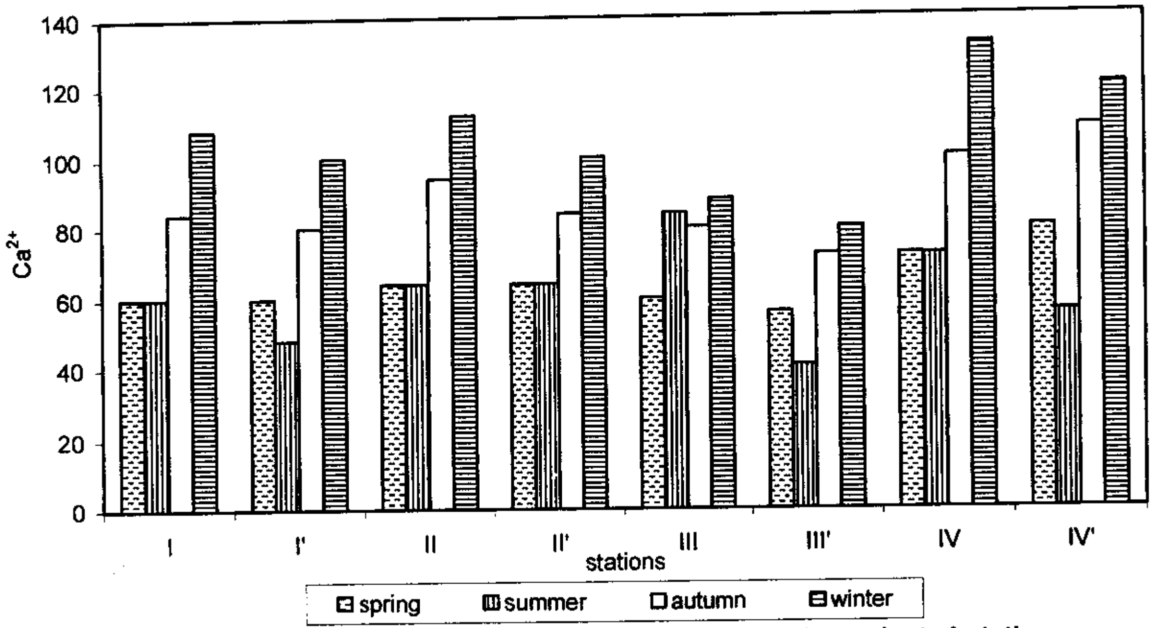
(iii) Calcium

Calcium is the most abundant dissolved cationic constituent of neutral fresh water, and is widely distributed in the minerals of rocks and soils. It is the fifth most abundant element on earth and it is found in every major land area in the world [92].

Seasonal variations of calcium at different selected stations of the area under investigation are presented in table (20) and graphically represented in figure (23).The range was found to be 60.12-72.3, 60.12-84.12, 80.16-100.2, 88.18-132.26 and 56.11-80.16, 40.8-64.12, 72.3-108.2, 80.19-120.24 mg/l before and after traditional treatment during spring, summer, autumn and winter seasons respectively .

Table (20): Seasonal variations of calcium (mg/l) at selected stations in studied area before and after traditional treatment during (2003-2004)

Seasons Stations		Spring	Summer	Autumn	Winter	Annual average	Standard deviation
I	I	60.12	60.12	84.17	108.2	78.15	23.02
	I'	60.12	48.1	80.16	100.2	72.15	22.91
II	II	64.12	64.12	94.2	112.2	83.66	23.73
	II'	64.12	64.12	84.16	100.2	78.15	17.47
III	III	60.12	84.17	80.16	88.18	78.16	12.46
	III'	56.11	40.8	72.3	80.16	62.34	17.51
IV	IV	72.3	72.14	100.2	132.26	94.23	28.58
	IV'	80.16	56.11	108.2	120.24	91.18	28.78



Figure(23): Seasonal variations of calcium (mg/l) at selected stations in the studied area before and after traditional treatment during (2003 - 2004)

The results for Ca^{2+} showed that the highest values were at station IV 132.26 mg/l in winter season and the lowest values were at station III' 40.8 mg/l in autumn season.

The higher concentration of calcium at station IV may be due to the increase in calcium content in the transit is probably due to the absorption of additional amount of calcium carbonate deposited earlier within the pipeline in the form of slime and incrustation.

The present results of Ca^{2+} indicate that there is an increases in Ca^{2+} contents of groundwater than surface water (23-54 mg/l) Abdo (2002) [95], and approximately in the ranges of (61 - 81 mg/l) of groundwater studied by present study.

The correlation coefficients of Ca^{2+} with TS, TDS, EC, Cl^-, HCO_3^-, ,SO_4^{2-} , P and TP were found to be of positive correlations during all seasons. For example HCO_3^- with Ca^{2+} ($r = 0.3, 0.4, 0.9, 1.0$) during summer, autumn, spring and winter seasons respectively. The negative correlations were represented with pH , Pb^{2+} and Zn^{2+}. For example pH with Ca^{+2} ($r = -0.4, -0.3, -0.6, -0.2$) during summer, autumn, spring and winter seasons respectively as shown in tables (36-39).

The correlation coefficients of Ca^{2+} with TS, TDS, HCO_3^- and Cl^- were found to give strong correlations during all stations. For example TS with Ca^{2+} ($r = 0.7, 0.7, 0.6, 1.0$) during station I, II, III and IV respectively. The negative correlations were represented with NO_2^-. For example NO_2^- with Ca^{2+} ($r = 0.0, 0.0, -0.7, -1.0$) during station I, II, III and IV respectively as shown in tables (40-43).

As a whole, calcium has a maximum level 200 mg/l in WHO, specification and Egyptian specification [18]. This means that, the Ca^{2+} values of the present study are in permissible limits.

(iv) Magnesium

Magnesium is also a major constituent of rocks. in abundance to second to calcium (about one fifth as mush). And usually found in occurrence with calcium [92].

Seasonal variations of magnesium at different selected stations of the area under investigation are presented in table (21) and graphically represented in figure (24). The range was found to be 107.36-126.8, 102.5-141.52, 63.48-187.8, 31.7-43.92 and 122-146.4, 112.24-139.1, 149.4-197.6, 36.6-51.24 mg/l before and after traditional treatment during spring, summer, autumn and winter seasons respectively.

In the same manner of other chemical parameters, magnesium were found in highest value at station IV and lowest value at station I 197.6 and 31.7 mg/l during summer and winter seasons respectively.

The values of magnesium in the ground water are higher compared with surface water (12-24 mg) in the River Nile water (Abdo,2002). This may be related to dissolution of some magnesium salts in the ground rocks of the area under investigation.

The other studies in greater Cairo showed that the magnesium concentration ranged between (4 -671 mg/l) [98].

The correlation coefficients of Mg^{2-} with TS, TDS, EC, Cl^-, HCO_3^-, ,SO_4^{2-} , P and TP were found to have positive correlations during all seasons. For example Cl^- with Mg^{2+} (r = 0.9, 0.6, 0.2, 0.6) during summer, autumn, spring and winter seasons respectively. The negative correlations were represented with pH , Pb^{2+} and Fe^{2+}. For example Fe^{2+} with Mg^{2+} (r = -0.4, -0.4, -0.1, -0.3) during summer, autumn, spring and winter seasons respectively as shown in tables (36-39).

Table (21): Seasonal variations of magnesium (mg/l) at selected stations in studied area before and after traditional treatment during (2003-2004)

Seasons Stations		Spring	Summer	Autumn	Winter	Annual average	Standard deviation
I	I	122	122	163.48	31.7	109.80	55.61
	I'	122	126.88	158.6	36.6	111.02	52.20
II	II	107.36	119.56	153.72	34.16	103.70	50.34
	II'	122	112.24	156.16	36.6	106.75	50.42
III	III	119.56	102.5	146.4	43.92	103.10	43.39
	III'	146.4	117.12	146.4	36.6	111.63	51.89
IV	IV	126.8	141.52	187.8	41.48	124.40	61.09
	IV'	139.1	139.1	197.6	51.24	131.76	60.35

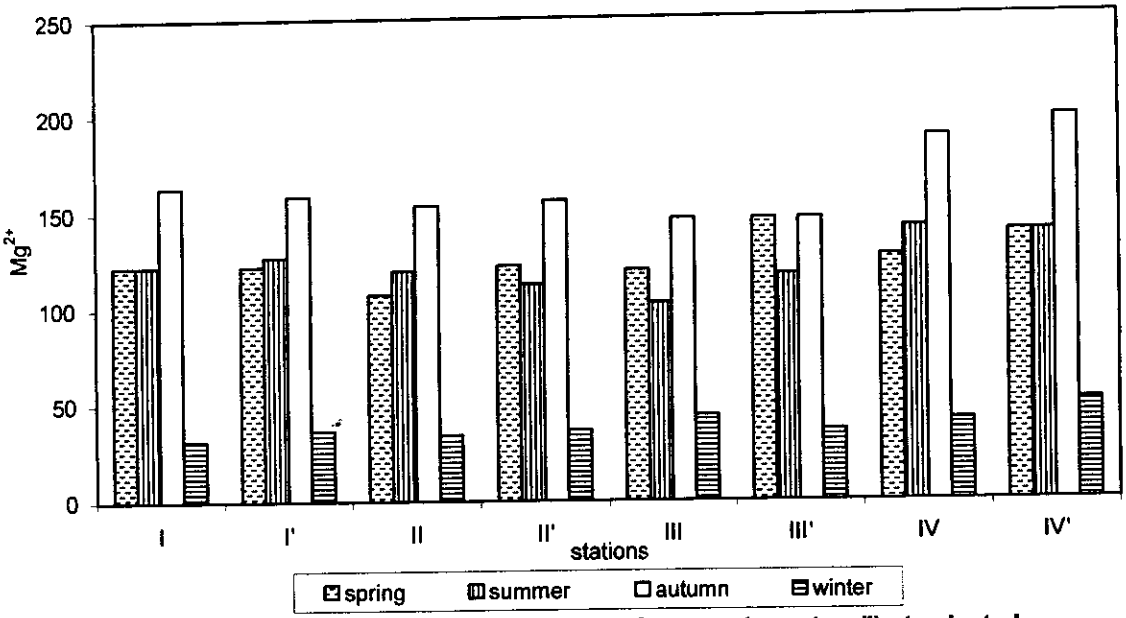


Figure (24): Seasonal variations of magnesium (mg/l) at selected stations in the studied area before and after traditional treatment during (2003 - 2004)

The correlation coefficients of Mg^{2+} with CO_3^{2-}, NO_3^- and NH_3 were found to have strong correlations during all stations. For example CO_3^{2-} with Mg^{2+} ($r = 0.3, 0.2, 0.4, 0.1$) during station I, II, III and IV respectively. The negative correlation were represented with EC, HCO_3^-, Cl^-, SO_4^{2-}, K^+ and P. For example HCO_3^- with Mg^{2+} ($r = -0.7, -0.8, -0.7, -0.5$) during station I, II, III and IV respectively as shown in tables (40-43).

WHO and Egyptian specification cited that the maximum level of Mg^{2+} 150 mg/l in the ground drinking water [18]. Therefore the ground water in the under investigation were within normal limits except for station I, II and IV during autumn season.

3.A.2.5. Nutrient salts:-

Similar to the importance of dissolved oxygen, temperature and pH in the aquatic environment, nutrient salts are also considered as very important compounds essential for the living organisms in natural and ground waters. At the same time, nutrient represents the fertility of the water [99].

(i) Nitrite

Anaerobic conditions may result in the formation and persistence of nitrite. Chloramination may give rise to the formation of nitrite within the distribution system if the formation of chloramines is not sufficiently controlled. The formation of nitrite is a consequence of microbial activity and may be intermittent. Nitrification in distribution systems can increase nitrite levels, usually by 0.2-1.5 mg/l [92].

The nitrite is the most unstable and rarely found in more than trace concentration in any water. This is partially oxidized state, occurs briefly as ammonia is oxidized or as nitrate is reduced [92].

Seasonal variations of nitrite at different selected stations of the area under investigation are presented in table (22) and graphically represented in figure (25).The range was found to be 1.3-13, 4.36-55.11, 4.8-17.84, 0-6.1 and 1.96-129.84, 0.65-5.01, 1.96-38.77, 0-8.06 µg/l before and after traditional treatment during spring, summer , autumn and winter seasons respectively.

The maximum value of NO_2^- reached 129.84 µg/l at station II' and was found nil at stations III & III' during spring and winter seasons respectively.

The results of NO_2^-, presented in table (22), revealed that NO_2^- values increased after treatment at station II during all seasons this mainly attributed to the treatment with on oxidation system leading to the oxidation of NH_3 to NO_2^- .

Also the comparison between NO_2^- values in surface water with the values of ground water in the present study indicated that surface water are higher than ground water .However the ranges of NO_2^- in Rosetta branch water was found to be (203-213 µg/l) Abdo(2002) [95].

The results of ground water in greater Cairo showed that the nitrite concentration ranged between (100 - 800µg/l) [98].

The correlation coefficients of NO_2^- with NO_3^-, pH were found to be of positive correlations during all seasons. For pH chloride with NO_2^- (r = 0.9, 0.9, 0.9, 0.3) during summer, autumn, spring and winter seasons respectively. The negative correlations were represented with Mn^{2+}. For example Mn with NO_2^- (r = -1.0, -0.6, -0.5, -0.6) during summer, autumn, spring and winter seasons respectively as shown in tables (36-39).

The correlation coefficients of NO_2^- with EC was found to have strong correlations during all stations. For example EC with NO_2^- (r = 0.2, 0.0, 0.1, 0.4) during station I, II, III and IV respectively. The negative correlations were represented with HCO_3^-, Mn^{2-} and Zn^{2-}. For example

Table (22): Seasonal variations of nitrite (µg/l) at selected stations in the studied area before and after traditional treatment during (2003-2004)

Seasons / Stations		Spring	Summer	Autumn	Winter	Annual average	Standard deviation
I	I	13	55.11	5.01	4.13	19.31	24.20
	I'	1.96	4.8	21.34	1.09	7.30	9.49
II	II	2.6	6.53	0.65	6.1	3.97	2.83
	II'	129.84	17.84	38.77	8.06	48.63	55.64
III	III	1.3	10.24	2.4	N.D.	3.49	4.61
	III'	10.9	10.24	10.2	N.D.	7.84	5.23
IV	IV	2.4	4.36	3.26	3.26	3.32	0.80
	IV'	2.4	7	1.96	5.66	4.26	2.46

N.D.: Not detected

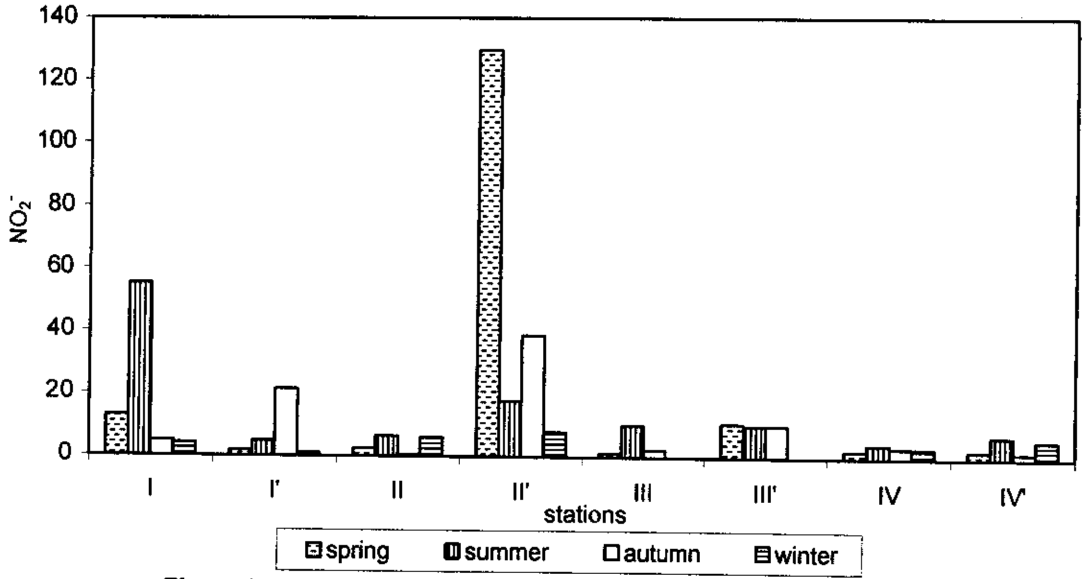


Figure (25): Seasonal variations of nitrite (µg/l) at selected stations in the studied area before and after traditional treatment during (2003 - 2004)

HCO_3^- with NO_2^- (r = -0.2, -0.5, -0.5, -0.7) during station I, II, III and IV respectively as shown in tables (40-43).

As a whole, nitrite is one of the primary contaminant having maximum level 0.005 mg/l in Egyptian specification as nitrogen [18]. The present values are higher than this level.

(ii) Nitrate

The nitrate concentration in groundwater and surface water is normally low but can reach high levels as a result of leaching or runoff from agricultural land or contamination from human or animal wastes as a consequence of the oxidation of ammonia and similar sources.

Nitrate is the most stable , oxidized form of nitrogen found in natural water [92].

Seasonal variations of nitrate at different selected stations of the area under investigation are presented in table (23) and graphically represented in figure (26).The range was found to be 85.25-119.53, 491.8-837, 26.71-40.17, 31.7-43.92 and 88.91-183.38, 10.76-55.75, 30.37-79.87, 36.6-51.24 µg/l before and after traditional treatment during spring, summer , autumn and winter seasons respectively .

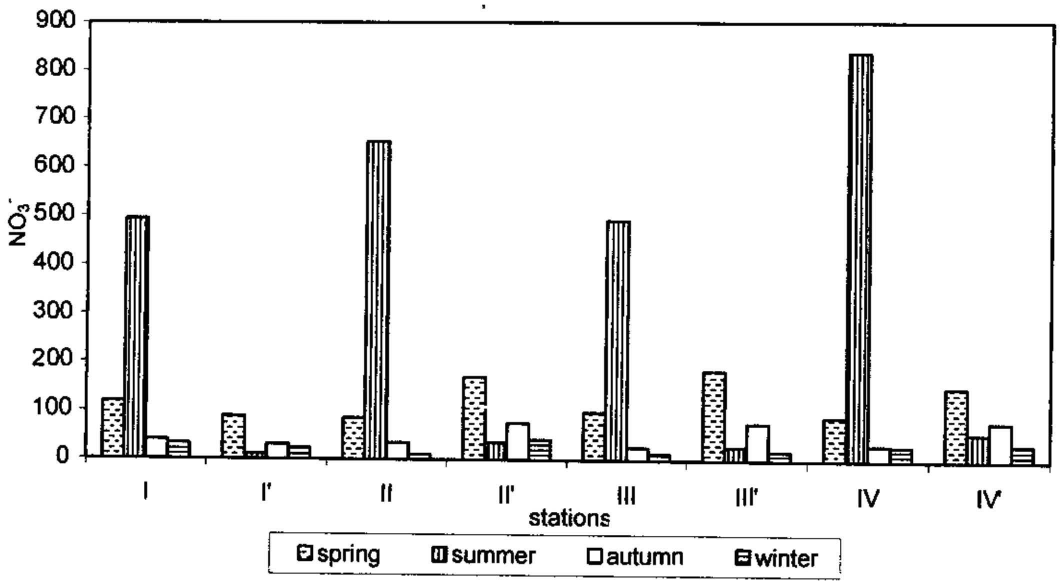
The maximum value of NO_3^- reached 837 µg/l and the minimum of 10.76 µg/l at stations IV & I' respectively during autumn season

The high concentration values of nitrate recorded at station IV during the investigation period may be due to contamination from fertilizers used as pesticides of agriculture lands in the area under investigation.

Also the comparison between the NO_3^- values in surface water and values of ground water in the present study, showed that the ground water are higher than surface water .However the ranges of NO_2^- in Rosetta branch was water (58.13-686.0 µg/l) Abdo(2002) [95].

Table (23): Seasonal variations of nitrate (μg/l) at selected stations in the studied area before and after traditional treatment during (2003-2004)

Seasons / Stations		Spring	Summer	Autumn	Winter	Annual average	Standard deviation
I	I	119.53	493.6	40.17	32.52	171.46	218.34
	I'	88.91	10.76	30.37	23.5	38.39	34.65
II	II	85.25	653.63	34.57	11	196.11	306.58
	II'	169.37	35.37	75.69	41.64	80.52	61.83
III	III	98.6	491.8	26.71	13.55	157.67	225.87
	III'	183.38	27.91	76.65	18.57	76.63	75.59
IV	IV	89.47	837	31.88	29.88	247.06	394.26
	IV'	150.71	55.75	79.87	33.45	79.95	50.84



Figure(26): Seasonal variations of nitrate(μg / l) at selected stations in the studied area before and after traditional treatmei during(2003 - 2004)

The correlation coefficients of NO_3^- with NO_2^- was found to give positive correlation during all seasons. For example NO_2^- with NO_3^- (r = 0.4, 0.5, 0.4, 0.3) during summer, autumn, spring and winter seasons respectively. The negative correlations were represented with pH and NO_2^-, Pb^{2+} and Zn^{2+}, For example Pb^{2+} with.NO_3^- (r = -06, -0.6, -0.6, -0.5) during summer, autumn, spring and winter seasons respectively as shown in tables (36-39).

The correlation coefficients of NO_3^- with EC and Mg^{2+} were found to give strong correlations during all stations. For example EC with NO_3^- (r = 0.2, 0.6, 0.9, 0.5) during station I, II, III and IV respectively as shown in tables (40-43).

As a whole nitrate, one of primary contaminants, has maximum level 10 µg/l in WHO, specification, Canadian specification, USA specification and Egyptian specification.

(iii) Ammonia

Ammonia nitrogen in aqueous solution either as ammonium ion [NH_4^+] or ammonia [NH_3] depending on the pH of the solution ,in accordance with the following equilibrium reaction.

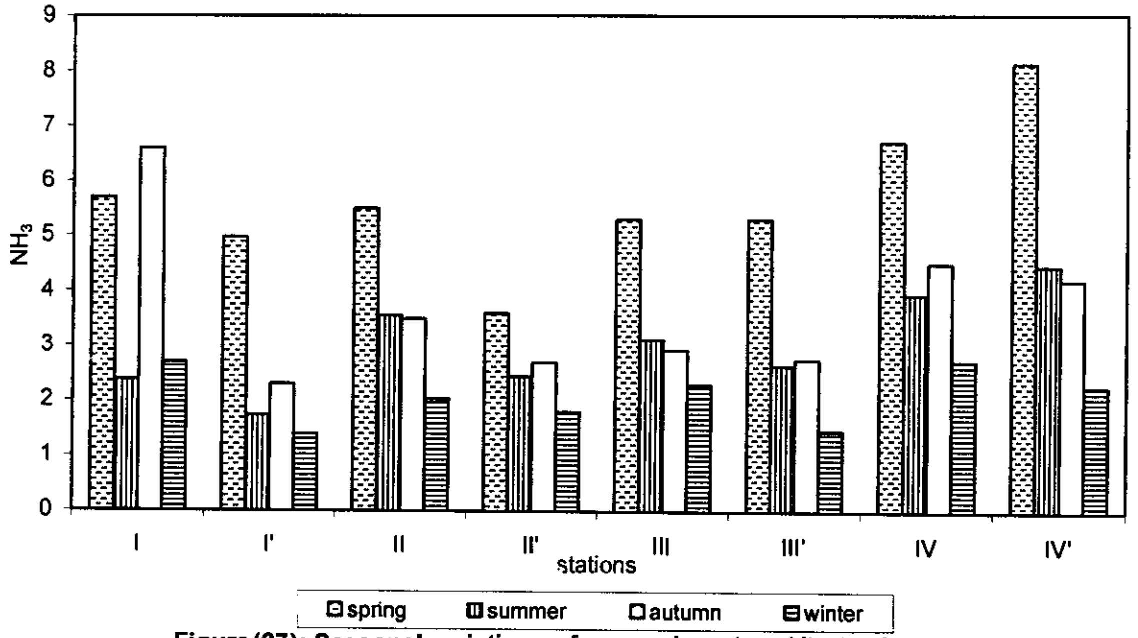
$NH_3 . H_2O \leftrightarrow NH_4^+ + OH^-$ [97] ....(3.3)

At pH above pH7, The equilibrium is displaced to the left, At pH less than7 , ammonium ion is predominant [95].

Seasonal variations of ammonia at different selected stations of the area under investigation are presented in table (24) and graphically represented in figure (27).The range was found to be 5.3-6.7, 2.38-3.94, 2.93-6.6, 1.04-2.74 and 3.6-8.13, 1.74-4.46, 2.3-4.2, 1.4-2.27 mg/l before and after traditional treatment during spring, summer , autumn and winter seasons respectively.

Table (24): Seasonal variations of ammonia (mg/l) at selected stations in the studied area before and after traditional treatment during (2003-2004)

Seasons Stations		Spring	Summer	Autumn	Winter	Annual average	Standard deviation
I	I	5.70	2.38	6.60	2.70	4.35	2.12
	I'	4.97	1.74	2.30	1.40	2.60	1.62
II	II	5.50	3.56	3.50	2.04	3.65	1.42
	II'	3.60	2.44	2.71	1.81	2.64	0.74
III	III	5.30	3.13	2.93	2.30	3.42	1.31
	III'	5.30	2.65	2.76	1.47	3.05	1.61
IV	IV	6.70	3.94	4.50	2.74	4.47	1.66
	IV'	8.13	4.46	4.20	2.27	4.77	2.45



Figure(27): Seasonal variations of ammonia (mg / l) at selected stations in the studied area before and after traditional treatment during (2003 - 2004)

The correlation coefficients of NH_3 with TDS, EC, HCO_3^-, Cl^-, SO_4^{2-} and K^+ were found to give positive correlations during all seasons. For example TDS with NH_3 (r = 0.5, 0.2, 0.8, 0.6) during summer, autumn, spring and winter seasons respectively. The negative correlations were represented with Pb^{2+}. For example Pb^{2-} with NH_3 (r = -0.5, -0.9, -0.8, -0.6) during summer, autumn, spring and winter seasons respectively as shown in tables (36-39).

The correlation coefficients of NH_3 with CO_3^{2-} and Mg^{2-} were found to have strong correlations during all stations. For example Mg^{2-} with NH_3 (r = 0.2, 0.8, 0.7, 0.8) during station I, II, III and IV respectively. The negative correlations were represented with Cl^-, SiO_2, P, Zn^{2-}. For example pH with NH_3 (r = -0.7, -0.7, -0.5, -0.6) during station I, II, III and IV respectively as shown in tables (40-43).

In the same manner for NO_2^- , NO_3^-, the maximum values of NH_3 were observed at station IV which reached 8.13 mg/l and the minimum values 1.04 mg/l at station I during spring and winter seasons respectively. The high values of ammonia concentrations recoded at station IV may be due to the contaminations with sewage and domestic wastes or related to the defect in the treatment process at this station.

(iv) Reactive silicate

Silicon is a non–metallic element present in cell wall of diatoms, representing 10 to 30 % of their dry weight [92] .

Seasonal variations of reactive silicate at different selected stations of the area under investigation are presented in table (25) and graphically represented in figure (28).The range was found to be 11.12-16.74, 14.13-20, 15.23-16.7, 17.26-22.2 and 10.6-14.3, 13.8-18.75, 15.7-18.02, 15.82-18.92 mg/l before and after traditional treatment during spring, summer , autumn and winter seasons respectively.

Table (25): Seasonal variations of silica (mg/l) at selected stations in the studied area before and after traditional treatment during (2003-2004)

Seasons / Stations		Spring	Summer	Autumn	Winter	A.A	S.D
I	I	14.00	16.70	15.51	22.20	17.10	3.57
	I'	11.20	14.00	17.15	18.92	15.32	3.42
II	II	11.12	20.00	16.70	19.31	16.78	4.03
	II'	14.30	16.60	15.70	17.42	16.01	1.34
III	III	13.00	14.13	15.23	17.26	14.91	1.81
	III'	10.60	13.80	18.02	15.82	14.56	3.15
IV	IV	16.74	16.70	18.30	18.92	17.67	1.12
	IV'	10.36	18.75	17.76	18.10	16.24	3.94

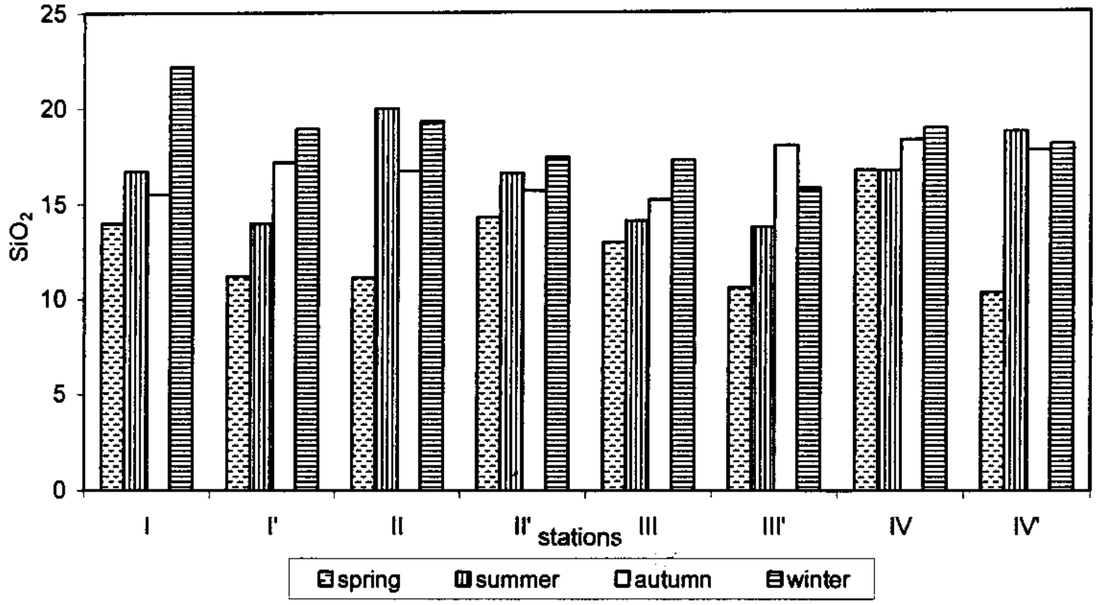


Figure (28): Seasonal variations of silica (mg / l) at selected stations in the studied area before and after traditional treatment during (2003 - 2004)

The highest values of SiO_2 reached 22.2 mg/l at station I and the lowest of them was 10.6 mg/l at station III during winter and spring seasons respectively.

The high concentration values of SiO_2 noticeable at station IV, may be attributed to the old and defects in the plane treatment in this station .

The comparison between SiO_2 concentrations in surface water (2.0-4 mg/l) Abdo (2002) [95] and ground water showed that the letter is rich in by silicate. This may be related to the dissolution of silicate from different rocks and sediments of the area under investigation.

The correlation coefficients of $SiO_2$with TDS, EC, HCO_3^-, Cl^- and K^+ were found to give positive correlations during all seasons. For example EC with SiO_2 (r = 0.5, 0.2, 0.2, 0.8) during summer, autumn, spring and winter seasons respectively. The negative correlations were represented with Pb^{2+}. For example Pb^{2+} with SiO_2 (r = -0.2, -0.5, -0.2, -0.5) during summer, autumn, spring and winter seasons respectively as shown in tables (36-39).

The correlation coefficients of SiO_2 with TS, TSS, COD and P were found to have strong correlations during all stations. For example TS with SiO_2 (r = 0.7, 0.5, 0.1, 0.2) during station I, II, III and IV respectively. The negative correlations were represented with CO_3^{2-}, Zn^{2+}. For example pH with SiO_2 (r = -0.4, -0.9, -0.7, -0.7) during station I, II, III and IV respectively as shown in tables (40-43).

The other ground water studies showed that silicate concentrations ranged between (107 - 17 mg/l) [98].

(v) Orthophosphate PO_4^{3-}

Phosphorous is a vital nutrient for all living organisms. Cellular phosphate compounds trap energy generated from food consumed and transfer it to activity that demands it: locomotion, reproduction and growth. Without phosphorous to built these energy compounds, cell life cannot exist [92].

Excessive phosphorous from run off or wastewater discharges in natural water bodies .however stimulate bacterial and algal growth. massive blooms may occur with resultant deposition of excessive solids [92].

Seasonal variations of orthophosphate at different selected stations of the area under investigation are presented in the table (26) and graphically represented in figure (29).The range was found to be 58.24-166.55, 92-145.10, 54.15-125.70, 100.14-255.45 and 18.4-122.61, 63.35-115.46, 94-109.33, 57.22-195.16 µg/l before and after traditional treatment during spring, summer , autumn and winter seasons respectively.

The maximum values of phosphate reached to 255.45 µg/l at station IV and the minimum 18.41 µg/l at station I during winter and spring seasons respectively.

As expected, the high values of PO_4^{3-} were observed at station IV which may be related to the defected in the treatment process in this station.

The correlation coefficients of P with TS, TDS, EC, HCO_3^-, Cl^-, K^+, Mg^{2+} were found to give positive correlation during all seasons. e.g. TS with P (r = 0.1, 0.5, 0.8, 0.9) during summer, autumn, spring and winter seasons respectively. The negative correlations were represented with pH. For example pH with P (r = -0.2, -0.2, -0.3, -0.3) during the same seasons as shown in tables (36-39).

The correlation coefficients of P with TS, TDS, TSS, Cl^-, K^- and SiO_2 were found to have strong correlation at all stations. For example TS with P (r = 0.6, 0.2, 0.5, 0.1) at stations I, II, III and IV respectively. The negative correlation were represented with CO_3^{2-}, Mg^{2-} and NH_3. e.g. NH_3 with P (r = -0.7, -0.7, -0.5, -0.6) at the same stations as shown in tables (40-43).

Table (26): Seasonal variations of phosphorous (µg/l) at selected stations in the studied area before and after traditional treatment during (2003-2004)

Seasons / Stations		Spring	Summer	Autumn	Winter	Annual average	Standard deviation
I	I	64.37	92.00	54.15	100.14	77.67	21.91
	I'	18.40	63.35	108.31	57.22	61.82	36.83
II	II	58.24	122.61	125.70	144.08	112.66	37.50
	II'	79.70	102.20	94.00	116.48	98.10	15.38
III	III	103.20	111.40	114.00	120.60	112.30	7.20
	III'	75.61	108.31	81.72	102.20	91.96	15.75
IV	IV	166.55	145.10	125.70	255.45	173.20	57.32
	IV'	122.61	115.46	109.33	195.16	135.64	40.05

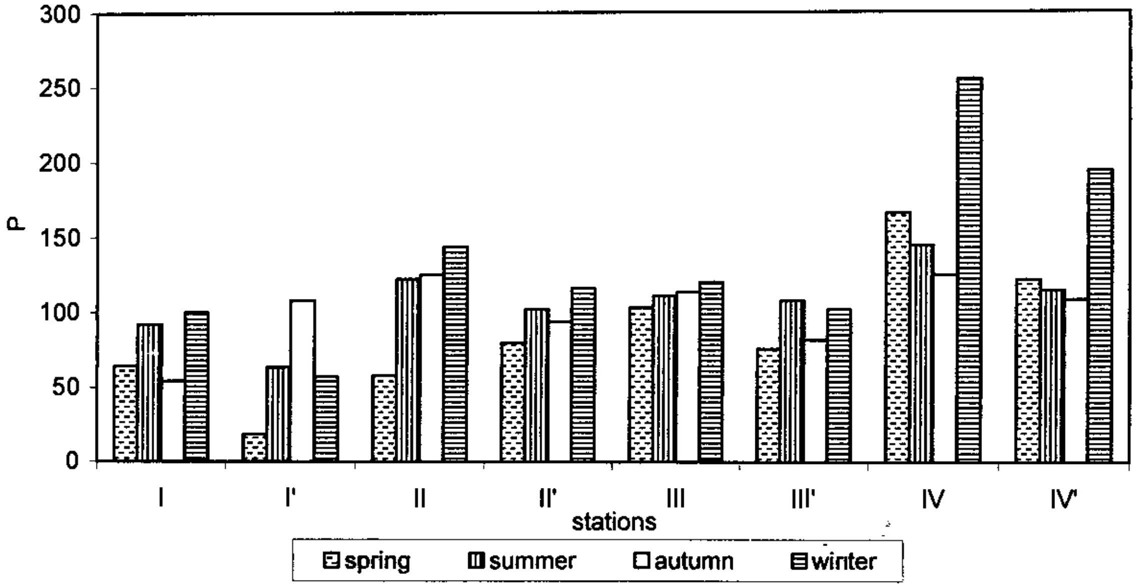


Figure (29): Seasonal variations of phosphorous (µg / l) at selected stations in the studied area before and after traditional treatment during (2003 - 2004)

Also The comparison between PO_4^{3-} concentrations in surface water (58.6-726μg/l) [95], and the values of PO_4^{3-} in present study, showed that The surface water is rich by phosphate. This may be related to contamination of surface water with fertilizers or chemical waste.

(vi) Total phosphorus(TP)

Total phosphate includes the organic and inorganic forms of reactive and inreactive phosphate. The total phosphorous is supplied from four sources: organic matter produced by living organisms, sediments, chemical reactions and from feeds or fertilizer [92].

Seasonal variations of total phosphate at different selected stations of the area under investigation are presented in able (27) and graphically represented in figure (30).The range was found to be 124.8-273, 116.5-236, 143-262.6, 163.5-816 and 192.1-211.51, 121.6-183.92, 147.14-222.75, 140.42-577.32 μg/l before and after traditional treatment during spring, summer , autumn and winter seasons respectively .

The maximum concentration values of TP reached 819 μg/l at station I and the minimum of 116.5 μg/l at station III during winter and summer seasons respectively.

As a result of bad techniques in the treatment process in station IV, the TP were found higher than any station in the area under investigation.

Also the comparison between the (TP) values in surface water with ground water values in the present study, showed that surface water are higher than ground water .However the ranges of (TP) in Rosetta branch water (81.4-1260.4 μg/l) Abdo (2002) [95].

The correlation coefficients of TP with TDS, HCO_3^-, Cl^-, K^+ and Fe^{2+} were found to be positive correlations during all seasons. e.g. Cl^- with TP (r = 0.8, 0.9, 0.4, 0.2) during summer, autumn, spring and winter

Table (27): Seasonal variations of total phosphate(μg/l) at selected stations in the studied area before and after traditional treatment during (2003-2004)

Seasons Stations		Spring	Summer	Autumn	Winter	Annual average	Standard deviation
I	I	268.73	168.60	143.00	819.00	349.83	317.45
	I'	140.00	125.70	147.14	577.32	247.54	220.03
II	II	124.80	170.60	192.10	269.75	189.31	60.53
	II'	192.10	156.30	187.00	140.42	168.96	24.74
III	III	222.75	116.50	149.18	163.50	162.98	44.44
	III'	169.62	121.60	167.80	143.88	150.73	22.68
IV	IV	273.00	236.00	262.60	387.26	289.72	66.87
	IV'	211.51	183.92	222.75	286.11	226.07	43.22

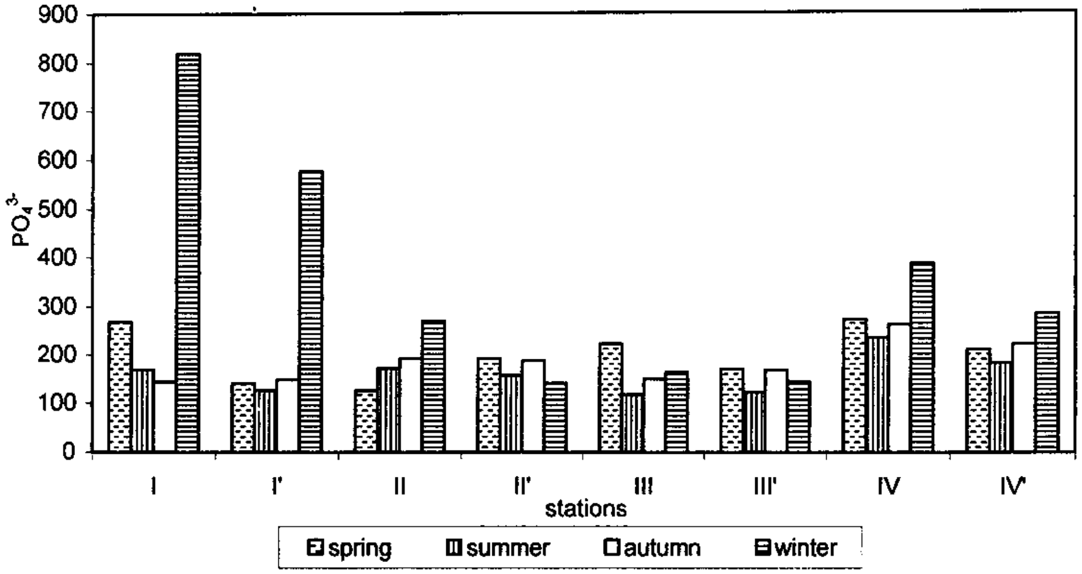


Figure (30): Seasonal variations of total phosphate(μg / l) at selected stations in the studied area before and after traditional treatment during(2003 - 2004) seasons respectively. The negative correlations were represented with pH, Zn^{2+} and Pb^{2+}. e.g. pH with TP (r = -0.3, -0.2, -0.4, -0.5) during the same seasons as shown in tables (36-39).

The correlation coefficients of TP with TDS, HCO_3^-, Cl^-, NO_3^-, SiO_2, Fe^{2+} were found to be strong correlations at all stations. Such as TDS with TP (r = 0.1, 0.3, 0.3, 0.12) at stations I, II, III and IV respectively. The negative correlations were represented with Pb^{2+}. For example Pb^{2+} with TP (r = -0.7, -0.3) at stations III and IV respectively as shown in tables (40-43).

Finally phosphorous have maximum level 5 mg/l European specification [18]. Thus the present values of phosphate are within normal limits.

3.A.2.6. Heavy metal ions :-

There are relations between the presence of heavy metal ions in drinking water and prevalence of renal failure, liver cirrhosis, hair loss and chronic diseases. The prevalence of these diseases markedly increased in last few years due to air pollution, water pollution, and hazards over uses of pesticides in agriculture. Iron, manganese and zinc are needed at low levels as catalysts for enzymes. Nickel and lead may be hazardous to our health [96].

Metals in our water supply may occur naturally or may be the results of contamination. Naturally occurring metal salts are dissolved in water when it comes into contact with rock or soil material. Other sources of metal ion contamination are corrosion of pipes and leakage from waste disposal sites [96].

(i) Iron

Iron is one of the most abundant metals in the Earth's crust. Water percolating through soil and rock dissolves iron with many others minerals and these minerals subsequently enter groundwater supplies [6].

Also, iron is an essential element in human nutrition. Estimates of the minimum daily requirement for iron depends on age, sex, physiological status and iron bioavailability, it ranges from about 10 to 50 mg/day [6].

Seasonal variations of iron at different selected stations of the area under investigation are presented in table (28) and graphically represented in figure (31).The range was found to be 1.8-2, 2.1-2.2, 2-2.2, 1.9-2.4 and 0.2-0.5, 0.3-0.9, 0.4-0.8, 0.5-1 mg/l before and after traditional treatment during spring, summer , autumn and winter seasons respectively.

The maximum concentration of Fe^{2-} was recorded at station IV and the minimum concentration at station I winch reached 2.3 mg/l and 0.2 mg/l during winter and spring seasons respectively.

The high value of iron concentrations was observed at station IV during the investigation period, may be due to the defects in the treatment plane of this station.

The pervious ground water studies reported that, the iron concentration ranged between (0.6 - 14.8 mg/l) [98].

Also the comparison between the Fe^{2-} values in surface water with the values of ground water in the present study, showed that surface water are lower than ground water .However the ranges of Fe^{2-} in Rosetta branch water was (0.2-1.5 mg/l) Abdo(2002) [95].

The correlation coefficients of Fe^{2-} with TSS and TP were found to have positive correlations during all seasons. e.g. TSS with Fe^{2-} ($r = 0.7$, 0.3, 0.1, 0.6) during summer, autumn, spring and winter seasons respectively. The negative correlations were represented with Mg^{2+}. e.g.

Table (28): Seasonal variations of iron (mg/l) at selected stations in the studied area before and after traditional treatment during (2003-2004)

Seasons / Stations		Spring	Summer	Autumn	Winter	Annual average	Standard deviation
I	I	2	2.1	2.2	1.9	2.05	0.11
	I'	0.2	0.3	0.4	0.5	0.35	0.11
II	II	1.9	2.2	2	2	2.025	0.11
	II'	0.5	0.9	0.8	0.7	0.725	0.15
III	III	1.8	2.1	2	2.3	2.05	0.18
	III'	0.2	0.8	0.7	0.9	0.65	0.27
IV	IV	1.9	2.1	2.1	2.4	2.125	0.18
	IV'	0.4	0.7	0.8	1	0.725	0.22

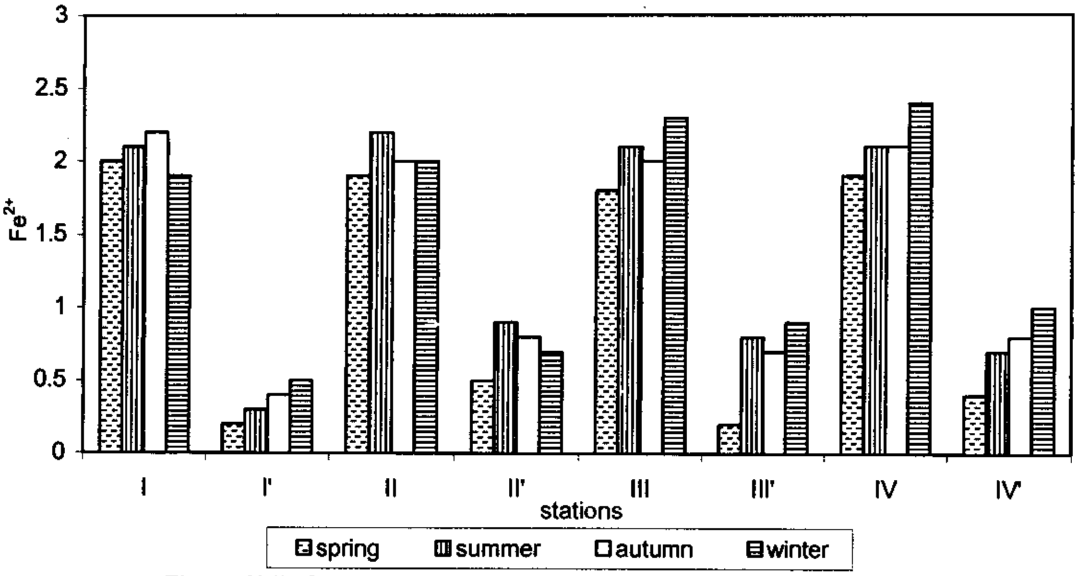


Figure (31): Seasonal variations of iron (mg/l) at selected stations in the studied area before and after traditional treatment during (2003 - 2004)

Mg^{2+} with Fe^{2+} (r = -0.4, -0.4, -1.0, -0.3) during the same seasons as shown in tables (36-39).

The correlation coefficients of Fe^{2-} with TSS, EC, TP and Mn were found to have strong correlations at all stations. e.g. Mn^{2+} with Fe^{2+} (r = 1.0, 1.0, 1.0, 1.0) at stations I, II, III and IV respectively. The negative correlations were represented between pH and Fe^{2-} (r = -1.0, -1.0, -0.6, -0.3) at stations I, II, III and IV respectively as shown in tables (40-43).

Generally iron is one of the secondary contaminant, which have maximum level 0.3 mg/l in WHO, European specification, Canadian specification, USA specification and Egyptian specification of surface water but ground water is 1 mg/l [18]. The iron values in the present study is considered as higher than this limit.

(ii) Manganese

Manganese is one of the most abundant metals in the earth's crust, usually occurring with iron. Water percolating through soil and rock dissolves manganese and many others minerals and these minerals subsequently enters groundwater supplies [6].

Seasonal variations of manganese at different selected stations of the area under investigation are presented in table (29) and graphically represented in figure (32).The range was found to be 3.2-3.9, 3.3-3.8, 3.2-3.7, 3.1-3.8 and 0.3-0.5, 0.3-0.6, 0.4-0.5, 0.2-0.5 mg/l before and after traditional treatment during spring, summer , autumn and winter seasons respectively.

The concentration of manganese showed that the highest values are found at station IV during spring season and the lowest at station III' during winter season which reached 3.9 mg/l and 0.2 mg/l respectively.

Table (29): Seasonal variations of manganese (mg/l) at selected stations in the studied area before and after traditional treatment during (2003-2004)

Seasons / Stations		Spring	Summer	Autumn	Winter	Annual average	Standard Deviation
I	I	3.5	3.5	3.2	3.1	3.325	0.18
	I'	0.5	0.5	0.4	0.5	0.475	0.04
II	II	3.2	3.3	3.4	3.5	3.35	0.11
	II'	0.4	0.3	0.4	0.5	0.4	0.07
III	III	3.7	3.4	3.5	3.7	3.575	0.13
	III'	0.3	0.4	0.5	0.2	0.35	0.11
IV	IV	3.9	3.8	3.7	3.8	3.8	0.07
	IV'	0.4	0.6	0.4	0.3	0.425	0.11

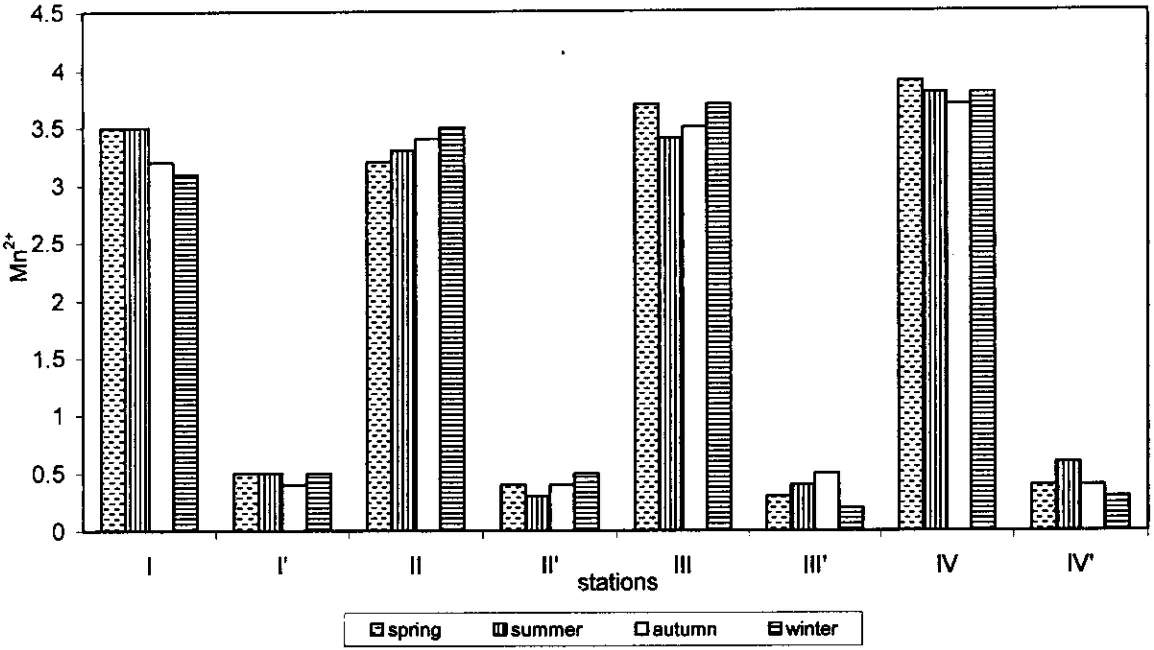


Figure (32): Seasonal variations of manganese (mg/l) at selected stations in the studied area before and after traditional treatment during (2003 - 2004)

Manganese is an essential element for humans and other animals. Adverse effects can result from both deficiency and overexposure. Manganese is known to cause neurological effects following inhalation exposure, particularly in occupational settings, and previous epidemiological studies reported adverse neurological effects following exposure to very high levels in drinking water.

The previous study showed that manganese concentration ranged between 2.87 mg/l [6].

Also the comparison between the Mn values in surface water with values of ground water in the present study, indicated that surface water are lower than ground water. However the ranges of Mn^{2+} in Rosetta branch water (27.8-373.6 μg/l) Abdo(2002) [95].

The correlation coefficient of Mn^{2+} with COD was found to be positive correlations during all seasons except the summer season. e.g. COD with Mn (r = -0.6, 0.1, 1.0 ,0.5) during summer, autumn, spring and winter seasons respectively. The negative correlations was represented between NO_2^- and Mn^{2+} (r = -1.0, -0.6, -0.5, -0.6) during summer, autumn, spring and winter seasons respectively as shown in tables (36-39).

The correlation coefficients of Mn with EC, Cl^- and Fe^{2+} were found to give strong correlations at all stations. e.g. EC with Mn^{2+} (r = 0.9, 0.2, 0.1, 0.1) at stations I, II, III and IV respectively. The negative correlations were represented with pH. e.g. pH with Mn^{2+} (r = -0.9, -0.9, -0.1, -0.2) during station I, II, III and IV respectively as shown in tables (40-43).

Finally manganese is one of secondary contaminants, which have maximum level 0.05 mg/l in European specification, Canadian specification and USA specification but Egyptian specification are 0.5 mg/l for ground water and 0.1g/l for surface water and WHO is 0.1 mg/l.

(iii) Zinc

Zinc is an essential element in living organisms being involved in synthesis of nucleic acid and occurring in many enzymes. It occurs widely in nature as sulphide, carbonate and hydrated silicate ores, frequently accompanied by other metals, mainly iron and cadmium. Zinc may occur in water as the free cation or soluble zinc complexes or can be adsorbed on suspended matter [97].

Seasonal variations of zinc at different selected stations of the area under investigation are presented in table (30) and graphically represented in figure (33).The range was found to be 0.336-0.5, 0.38-0.562, 0.43-0.52, 0.314-0.55 and 0.422-0.54, 0.4-0.758, 0.366-0.52, 0.26- 1.108 mg/l before and after traditional treatment during spring, summer , autumn and winter seasons respectively .

The maximum concentration values of zinc reached 1.108 mg/l and the minimum values of 0.26 mg/l at stations III' and VI' respectively during winter season.

The high values of zinc concentration at all studied stations mainly attributed to the contamination effect from different components of the treatment system. But all values were found within the permissible limits of WHO, Roan, USA and Egyptian specifications; the latter cited the maximum level of Zn^{2+} 5 mg/l [18].

The previous study in great Cairo reported that zinc concentration ranged between (0.29 - 0.4 mg/l) [18].

The correlation coefficients of Zn^{2+} with pH was found to have positive correlations during all seasons except the summer and spring seasons (r = -0.6, 0.2, -1.0, 0.5) during summer, autumn, spring, winter seasons respectively. The negative correlations were represent with TDS,

Table (30): Seasonal variations of zinc(mg/l) at selected stations in the studied area before and after traditional treatment during (2003-2004)

Seasons / Stations		Spring	Summer	Autumn	Winter	Annual average	Standard Deviation
I	I	0.378	0.380	0.476	0.436	0.42	0.05
	I'	0.428	0.758	0.366	0.560	0.53	0.17
II	II	0.426	0.440	0.430	0.470	0.44	0.02
	II'	0.422	0.400	0.520	0.460	0.45	0.05
III	III	0.500	0.562	0.520	0.550	0.53	0.03
	III'	0.508	0.490	0.480	1.108	0.65	0.31
IV	IV	0.336	0.500	0.460	0.314	0.40	0.09
	IV'	0.540	0.556	0.516	0.260	0.47	0.14

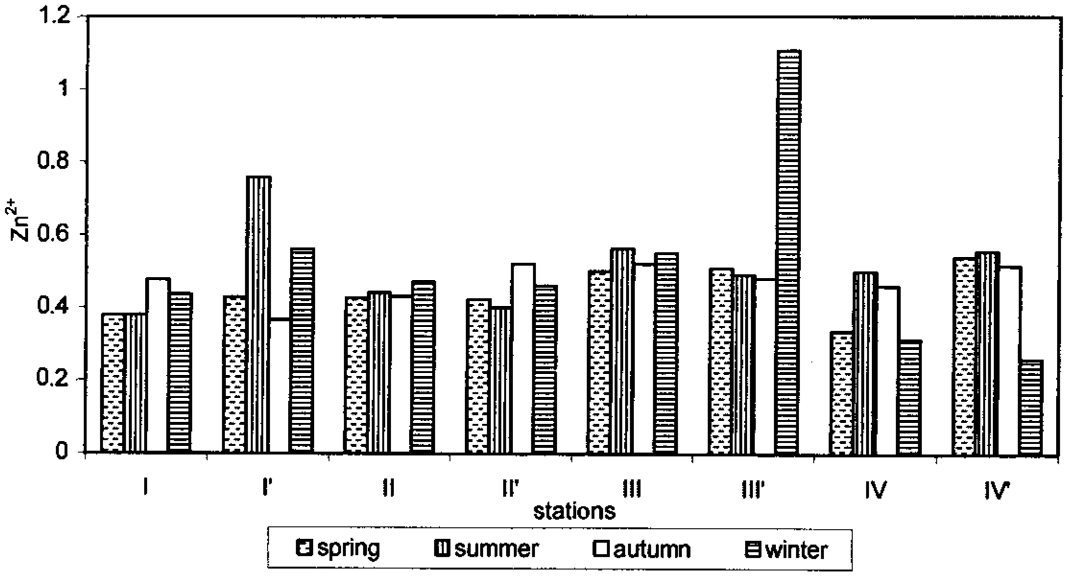


Figure (33): Seasonal variations of zinc (mg/l) at selected stations in the studied area before and after traditional treatment during (2003 - 2004)

Cl^-, EC, SO_4^{2-} and TP. e.g. TP with Zn^{2+} ($r = -0.7, -0.4, -0.9, -0.4$) during the same seasons as shown in tables (36-39).

The negative correlations were represented with TS, TDS,TSS, EC, CO_3^{2-}, Na^+ and NO_2^-. e.g. pH with Zn^{2+} ($r = -0.2, -0.1, -1.0$) at stations I, II and IV respectively as shown in tables (40-43).

Also the comparison between the Zn^{2+} values in surface water with the values of ground water in the present study indicated that the surface water are lower than ground water. However, the ranges of Zn^{2+} in Rosetta branch water was (10-166 µg/l) Abdo(2002) [95].

(iv) Lead

Lead is one the primary contaminant pollutants in drinking water. Lead is found naturally in rocks and soil. In many countries, air is polluted with high concentrations of lead as a result of combustion of leaded gasoline (mainly petrol cars) and flue exhaust gases from lead smelters. Such lead contaminates are recycled to the soil via rains and possibly contaminate the groundwater aquifers. Lead as hazardous waste pollutant, may pollute the groundwater [92].

Drinking water supplies may also be contaminated with high concentrations of lead due to leaching from the plumbing products (faucets, pipe soldering, ...etc.). Lead is exceptional in that most lead in drinking water arises from plumbing in buildings and the remedy consists principally of removing plumbing and fittings containing lead [92].

Seasonal variations of lead at different selected stations of the area under investigation are presented in table (31) and graphically represented in figure (34).The range was found to be N.D.-0.142, 0.006-0.104, 0.006-0.17, N.D.-0.138 and 0.0-0.128, N.D.-0.2, 0.006-0.078, N.D.-0.15 mg/l before and after traditional treatment during spring, summer , autumn and winter seasons respectively.

The maximum values of lead reached to 0.2 mg/l at station II' and the lowest of them 0.024 mg/l at station I' during summer and winter seasons respectively. It was not detected at station IV during different seasons.

The higher concentration of lead at station II, which reached 0.2, may be due to the contamination of ground water with any impurities introduced in the treatment process.

High level of exposure to lead in drinking water can cause brain damage, stunt growth, damage of kidneys, impair hearing, vomiting, headaches, appetite loss and hypertension. This colorless, odorless and tasteless metal ion can go virtually undetected in water [92].

The comparison between Pb^{2-} values in surface water with the values of ground water in the present study, indicated that the surface water are lower than ground water. However, the ranges of Pb^{2+} in Rosetta branch water was (24.4 -152.8 μg/l) Abdo (2002) [95].

The correlation coefficients of Pb^{2-} with pH was found to have positive correlations during all seasons. e.g. pH with Pb^{2+} (r = 0.5, 0.3, 1.0, 0.7) during summer, autumn, spring and winter seasons respectively. The negative correlations were represented with TS, TDS, EC, HCO_3^-, Cl^-, SO_4^{2-}, K^+, Mg^{2+}, NH_3, SiO_2 and TP. e.g. TS with Pb^{2-} (r = -0.2, -0.5, -0.8, -0.6) during the same seasons as shown in tables (36-39).

Table (31): Seasonal variations of lead(mg/l) at selected stations in the studied area before and after traditional treatment during (2003-2004)

Seasons / Stations		Spring	Summer	Autumn	Winter	Annual average	Standard Deviation
I	I	0.072	0.056	0.028	0.052	0.052	0.018
	I'	0.060	0.062	0.046	0.024	0.048	0.018
II	II	0.142	0.094	0.170	0.138	0.136	0.031
	II'	0.128	0.200	0.078	0.150	0.139	0.051
III	III	0.056	0.104	0.056	0.068	0.071	0.023
	III'	0.068	0.120	0.056	0.100	0.086	0.029
IV	IV	N.D.	0.006	0.006	N.D.	0.003	0.003
	IV'	N.D.	N.D.	0.006	N.D.	0.002	0.003

N.D.: Not detected

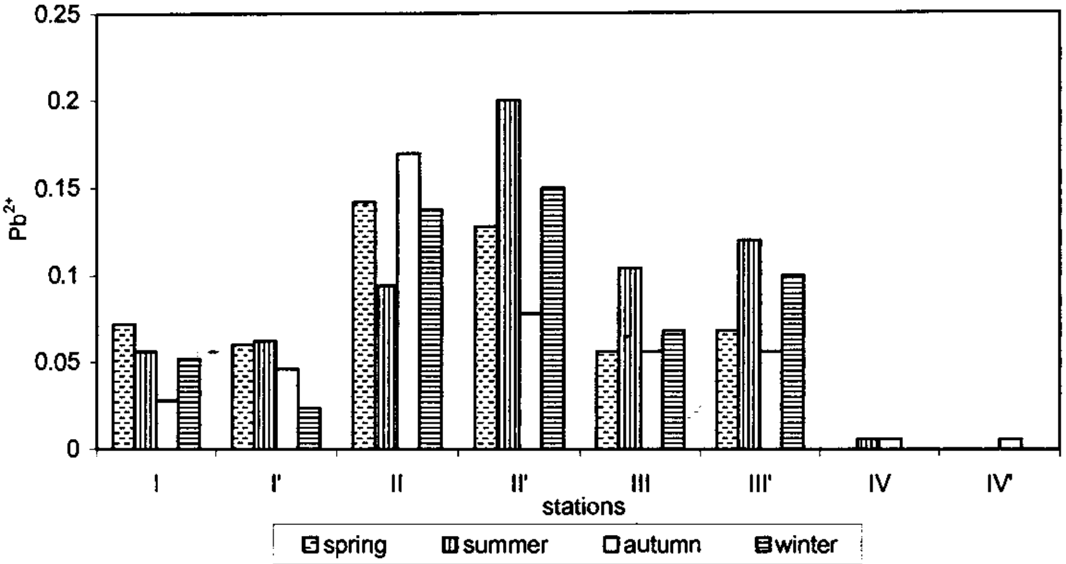


Figure (34): Seasonal variations of lead (mg/l) at selected stations in the studied area before and after traditional treatment during (2003 - 2004)

The correlation coefficients of Pb^{2+} with TSS and EC were found to give strong correlations at all stations. e.g. TSS with Pb^{2+} (r = 0.3, 0.5, 0.6, 0.2) at stations I, II, III and IV respectively. The negative correlations were represented between pH and Pb^{2+} (r = -0.1, -0.3, -0.3, -0.6) at the same stations as shown in tables (40-43).

Generally, lead is one of the primary contaminants, which have maximum level 0.05 mg/l in WHO , European specification ,Canadian specification , USA specification and Egyptian specification [18]. Therefore the present concentration of Pb^{2+} are higher than this limits.

(v) Cadmium

Contamination of drinking water with Cd^{2+} may occur as a result of the presence of cadmium as an impurity in zinc of galvanized pipes or cadmium containing solders in fittings, water heaters, water coolers, and taps [93].

Levels of cadmium could be higher in areas supplied with soft water of low pH, as this would tend to be more corrosive in plumbing systems containing cadmium. Cadmium can cause kidney failure and hypertension [6].

Cadmium was not detected at all studied stations during the period of investigation. This reveals that the ground water of the studied area are not contaminated by cadmium. This may be due to void of contamination source of cadmium.

Also, the comparison between Cd^{2+} values in surface water with the values of ground water in the present study showed that Cd^{2+} concentration in the surface water are higher than ground water. However, the ranges of Cd^{2+} in the Rosetta branch water was (3-15 μg/l) Abdo(2002) [95].

Generally, cadmium is one of primary contaminants, the maximum level 0.005 mg/l cited by WHO, European specification, Canadian specification, and Egyptian specification. But USA specification is 0.01mg/l.

(vi) Nickel

Nickel concentrations in drinking water around the world are normally below 20 µg/l, although levels up to several hundred micrograms per liter were found in groundwater and drinking water [93].

Also nickel was not detected at all studied stations during the period of investigation. This means that the areas studied are not contaminated by Ni^{2+} in of the studied groundwater. This may be due to void of contamination severe of nickel [93].

Generally nickel is one of the primary contaminants, the maximum level of nickel is 0.05 mg/l as cited by European specification, and 0.01 mg/l in federal specification [93].

The data listed in tables (32-35) show the concentration levels of the physicochemical in (ppm) of the four stations (I, II, III and IV) during four seasons. Traditional treatment technique at the four stations was applied (aeration, oxidation, filtration and chlorination) and aimed to reduce the concentration of iron and manganese only to the permissible limits (1 and 0.5 ppm) respectively.

From the previous discussion we can conclude that; as shown in tables (31-34), it can be seen that all parameters cited before and after treatment are within normal limits according to WHO and Egyptian specification except the following ones:

(i) iron and manganese levels before treatment exceeded the permissible levels and thus its treatment is a must.

(ii) Lead is out of limits (more than 0.05 mg/l) almost in all stations at all seasons (except station IV in the all seasons, station I in autumn).

(iii) Iron and manganese after treatment are within the permissible limit according to the specification (except manganese in station IV in summer season).

(iv) TDS before and after treatment are within the normal limits (1200 mg/l) except station IV in all seasons. This may be due to contamination of the wells with fertilizers and some industrial pollutants. Similar is behavior observed for TS in station IV in autumn and winter seasons.

(v) Iron is high with positive correlation (r =1) with manganese as shown by scatter plot in fig (35).

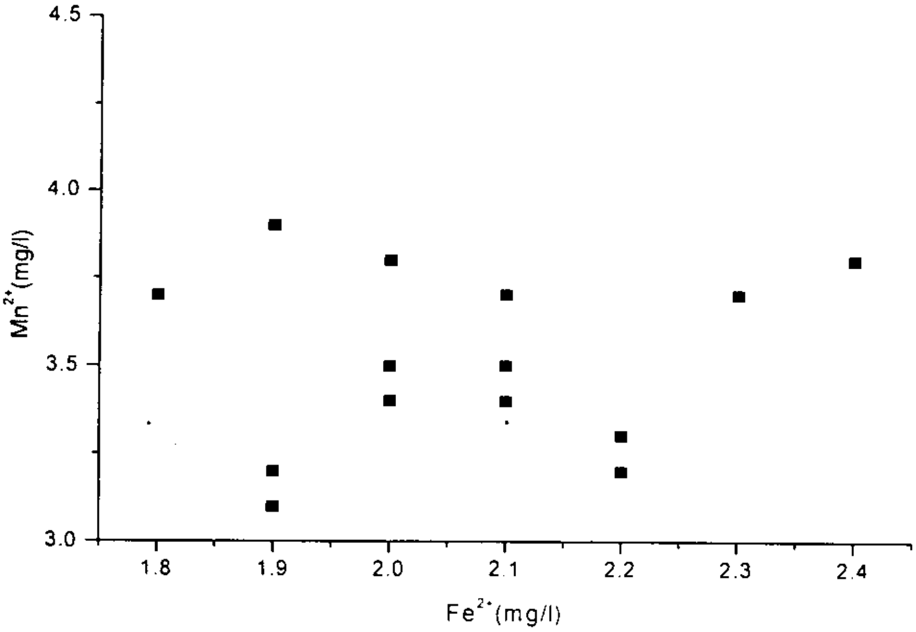


Fig.(35) Relationship between Iron and Manganese concentrations (mg/l) during-seasons in area under investigations

Table (32) Variations of physicochemical parameters in spring season

		Stations Parameters	I	I'	II	II'	III	III'	VI	VI'
PHYSICAL PARAMETERS		TS mg/l	864	918	890	940	944	920	1381	1357
		TDS mg/l	796	850	902	900	920	882	1245	1317
		TSS mg/l	58	62	88	40	24	18	136	40
		EC µmohs/cm	700	754	881	873	800	750	1305	1331
CHMICAL PARAMETERS	pH		8. 24	8.12	8. 30	8.21	8.12	8. 26	8.09	8.06
	OXYGEN STUDIES	COD mg/l	2	2	1.6	1. 2	2.4	2	0.8	1.2
	MAJOR ANIONS	CO_3^{--} mg/l	15	5	15	10	10	10	10	10
		HCO_3^- mg/l	461.7	469.8	453.6	453.6	558. 9	494.1	696.6	737.1
		Cl^- mg/l	71	71	99	99	85	71	156	156
		SO_4^{--} mg/l	39.12	89. 26	97.8	98.8	42. 2	54. 23	107. 21	112.16
	MAJOR CATIONS	Na^+ mg/l	32. 5	32. 5	51.42	51.42	48.7	51.42	81. 2	81. 2
		K^+ mg/l	7.65	6.75	7.65	7.45	7.25	7.35	13.4	12.7
		Ca^{++} mg/l	60.12	60.12	64.12	64.12	60.12	56.11	72. 3	80.16
		Mg^{++} mg/l	122	122	107. 36	122	119. 56	146.4	126.8	139.1
	NUTRIENT SALTS	NO_2^- µg/l	13	1.96	2.6	129.84	1.3	10.9	2.4	2.4
		NO_3^- µg/l	119. 53	88. 91	85. 25	169. 37	98.6	183. 38	89.7	150.71
		NH_3 mg/l	5.7	4.97	5.5	3.6	5.3	5.3	6.7	8.13
		SiO_2 mg/l	14	11.2	11.12	14.3	13	10.6	16.74	10.36
		P µg/l	64. 37	18.4	58. 24	79.7	103. 2	75.61	166. 55	122.61
		TP µg/l	268.73	140	124.8	192.1	222.75	169.62	273	211. 51
	Heavy metals	Fe^{2+} mg/l	2	0. 2	1.9	0. 5	1.8	0. 2	1.9	0.4
		Mn^{2+} mg/l	3. 5	0. 5	3. 2	0.4	3.7	0. 3	3. 9	0.4
		Zn^{2+} mg/l	0. 378	0.428	0.426	0.422	0. 5	0. 508	0. 336	0. 540
		Pb^{2+} mg/l	0.072	0.06	0.142	0.128	0.056	0.068	n.d.	n.d.
		Cd^{2+} mg/l	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		Ni^{2+} mg/l	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

n.d.: not detected

Table (33) Variations of physicochemical parameters in summer season

		Stations Parameters	I	I'	II	II'	III	III'	VI	VI'
PHYSICAL PARAMETERS		TS mg/l	1020	854	996	1023	1887	923	1350	1297
		TDS mg/l	840	814	900	847	947	871	1282	1269
		TSS mg/l	180	40	96	176	140	82	68	28
		EC µmohs/cm	800	770	960	920	990	800	1510	1510
CHMICAL PARAMETERS		pH	7. 32	7.25	7.37	7.70	7.40	7.86	7.41	7.47
	OXYGEN STUDIES	COD mg/l	2.4	3.2	5.2	6.8	6	6.4	4.8	5.6
	MAJOR ANIONS	CO_3^{--} mg/l	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		HCO_3^- mg/l	486	486	478	478	543	478	664.2	648
		Cl^- mg/l	81.5	78	117	96	106. 3	78	195	212
		SO_4^{--} mg/l	43.21	35.16	75.65	88.15	73.7	57.07	113.77	117.86
	MAJOR CATIONS	Na^+ mg/l	39	35.67	45.18	52.32	36.26	52.8	84.67	84.67
		K^+ mg/l	7.75	6.51	6.51	7.43	7.43	7.13	12.4	12.07
		Ca^{++} mg/l	60.12	48.1	64.12	64.12	84.17	40.8	72.14	56.11
		Mg^{++} mg/l	122	126.88	119..56	1112. 24	102. 5	117.12	141. 52	139.1
	NUTRIENT SALTS	NO_2^- µg/l	55.11	4.8	6.53	17.84	10. 24	10. 24	4. 36	7
		NO_3^- µg/l	493.6	10.76	653.63	35.37	491.8	27. 91	837	55.75
		NH_3 mg/l	2.38	1.74	3.56	2.44	3.13	2.65	3.94	4.46
		SiO_2 mg/l	16.7	14	20	16.6	14.13	13.8	16.7	18.75
		P µg/l	92	63. 35	122.61	102. 2	111.4	108. 31	145.1	115.46
		TP µg/l	168.6	125.7	170	156. 3	116. 5	121.6	236	183.92
	Heavy metals	Fe^{2+} mg/l	2.1	0. 3	2. 2	0. 9	2.1	0.8	2.1	0.7
		Mn^{2+} mg/l	3. 5	0. 5	3.3	0. 3	3.4	0.4	3.8	0.6
		Zn^{2+} mg/l	0.38	0.758	0.44	0.4	0. 562	0.49	0. 5	0. 556
		Pb^{2+} mg/l	0.056	0.062	0.094	0.2	0.104	0.12	0.006	n.d.
		Cd^{2+} mg/l	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		Ni^{2+} mg/l	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

n.d.: not detected

Table (34) Variations of physicochemical parameters in autumn season

		Stations / Parameters	I	I'	II	II'	III	III'	VI	VI'
PHYSICAL PARAMETERS		TS mg/l	991	1034	1083	1073	1049	978	1714	1607
		TDS mg/l	971	990	1007	1005	977	884	1534	1575
		TSS mg/l	20	64	76	68	72	64	180	32
		EC μmohs/cm	866	716	793	810	750	657	1380	1420
CHMICAL PARAMETERS	pH		7.66	7.96	7.85	8.27	7.66	8.19	7.69	7.64
	OXYGEN STUDIES	COD mg/l	8	4	4	4.4	2.4	2.4	2.4	4.4
	MAJOR ANIONS	CO_3^{--} mg/l	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		HCO_3^- mg/l	551	527	527	494.1	567	494	770	794
		Cl^- mg/l	110	90	100	110	84	70	234	228
		SO_4^{--} mg/l	97.43	79. 36	77.75	93.47	40.61	46.97	134.7	135
	MAJOR CATIONS	Na^+ mg/l	45.85	43. 3	48.4	51	50	49.03	92. 34	93.62
		K^+ mg/l	7.25	6. 92	6.05	6.37	7. 25	6.71	13	13
		Ca^{++} mg/l	84.17	80.16	94. 2	84.16	80.16	72.3	100. 2	108. 2
		Mg^{++} mg/l	63.48	158.6	153.72	156.16	146.4	146.4	187.8	197.6
	NUTRIENT SALTS	NO_2^- μg/l	5.01	21.34	0.65	38.77	2.4	10. 2	3. 26	1.96
		NO_3^- μg/l	40.17	30. 37	34. 57	75.69	26.71	76.65	31.88	79.87
		NH_3 mg/l	6.6	2. 3	3. 5	2.71	2. 93	2.76	4. 5	4. 2
		SiO_2 mg/l	15. 5	17.15	16.7	15.7	15. 23	18.02	18. 3	17.76
		P μg/l	54.15	108. 31	125.7	94	114	81.72	125.7	109.33
		TP μg/l	143	147.14	192.1	187	149.18	167.8	262.6	222.75
	Heavy metals	Fe^{2+} mg/l	2.2	0.4	2	0.8	2	0.7	2.1	0.8
		Mn^{2+} mg/l	3.2	0.4	3.4	0.4	3. 5	0. 5	3.7	0.4
		Zn^{2+} mg/l	0.476	0. 366	0.43	0. 52	0. 52	0.48	0.46	0. 516
		Pb^{2+} mg/l	0.028	0.046	0.17	0.078	0.056	0.056	0.006	0.006
		Cd^{2+} mg/l	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
		Ni^{2+} mg/l	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

n.d.: not detected

(iii)Correlation coefficient "r "

The correlation coefficient "r " was applied in details for different parameters seasonally and in different stations as shown in tables (36-43) respectively.

As shown in Table (44) the concentration of iron and manganese in the area under investigation are higher values in comparison with other sites in greater Cairo .

As shown in table (45), there is no variation of all physico-chemical parameters in all seasons for the area under investigation before and after treatment except iron and manganese which reach the permissible level after traditional treatment compared to water specification .

Table (36) Correlation coefficient matrix of physicochemical parameters during spring season

	TS	TDS	TSS	EC	pH	COD	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Na^+	K^+	Ca^{2+}	Mg^{2+}	NO_2^-	NO_3^-	NH_3	SiO_2	P	TP	Fe^{2+}	Mn^{2+}	Zn^{2+}	Pb^{2+}
TS	1.0																							
TDS	1.0	1.0																						
TSS	0.4	0.4	1.0																					
EC	1.0	1.0	0.5	1.0																				
pH	-0.7	-0.7	-0.3	-0.6	1.0																			
COD	-0.9	-0.8	-0.7	-0.8	0.8	1.0																		
CO_3^{2-}	-0.2	-0.1	0.1	-0.1	0.0	-0.1	1.0																	
HCO_3^-	1.0	1.0	0.3	0.9	-0.8	-0.9	-0.2	1.0																
Cl^-	0.9	1.0	0.5	1.0	-0.6	-0.9	0.0	0.9	1.0															
SO_4^{2-}	0.8	0.7	-0.2	0.8	-1.0	-0.9	-0.5	0.5	0.8	1.0														
Na^+	-0.8	-0.8	0.4	0.3	1.0	-0.9	0.3	0.0	0.2	0.0	1.0													
K^+	1.0	1.0	0.5	1.0	-0.7	-0.9	0.0	1.0	1.0	0.5	0.7	1.0												
Ca^{2+}	0.9	0.9	0.1	1.0	-0.8	-0.8	0.0	0.9	1.0	0.7	0.2	0.9	1.0											
Mg^{2+}	0.2	0.3	-0.4	0.2	-0.7	0.0	0.0	0.4	0.2	0.6	0.0	0.2	0.2	1.0										
NO_2^-	-0.2	-0.2	-0.2	-0.1	0.9	0.3	0.0	-0.3	-0.1	0.2	0.4	-0.2	0.0	-0.3	1.0									
NO_3^-	0.3	0.5	-0.5	0.4	-0.8	-0.1	0.0	1.0	0.4	0.0	0.0	0.3	1.0	1.0	0.4	1.0								
NH_3	0.8	0.8	0.3	0.7	-0.9	-0.7	0.1	0.9	0.7	0.2	-0.3	0.8	0.7	0.4	-0.8	0.8	1.0							
SiO_2	0.3	0.1	0.6	0.2	0.3	-0.4	0.1	0.1	0.3	-0.6	-0.3	0.3	-0.3	-0.8	0.3	-0.9	-0.1	1.0						
P	0.8	0.8	-0.5	0.8	-0.3	-0.8	0.9	0.8	0.8	1	0.0	0.8	0.7	0.5	0.1	0.0	0.6	-0.1	1.0					
TP	0.5	0.4	0.3	0.4	-0.4	-0.3	0.2	0.8	0.4	-0.9	-0.7	0.6	-0.2	-0.3	0.0	-1.0	0.5	0.8	0.9	1.0				
Fe^{2+}	-1.0	-1.0	0.1	-1.0	1.0	0.9	0.6	-1.0	-1.0	-1	0.0	-1.0	-1.0	-1	0.5	-1.0	-1.0	1.0	0.0	1.0	1.0			
Mn^{2+}	-0.5	-0.5	-1	-0.8	-0.1	1.0	0.0	0.0	-0.7	0.0	-1	-0.5	-0.7	0.0	-0.5	-1.0	-0.1	0.2	0.0	1.0	1.0	1.0		
Zn^{2+}	-0.8	-0.7	0.8	-0.7	-1.0	1.0	-0.3	0.8	-0.8	-1.0	0.0	-0.6	-0.8	0.0	-0.9	0.0	0.8	-0.9	-1.0	-0.9	0.0	0.0	1.0	
Pb^{2+}	-0.8	-0.7	-0.2	-0.8	1.0	0.5	0.4	-0.9	-0.8	-0.1	0.7	-0.7	-0.4	-0.3	0.5	-0.4	-0.8	-0.2	-0.4	-0.6	1.0	-0.1	-0.6	1.0

Table (37) Correlation coefficient matrix of physicochemical parameters during summer season

	TS	TDS	TSS	EC	pH	COD	HCO_3^-	Cl^-	SO_4^{2-}	Na^+	K^+	Ca^{2+}	Mg^{2+}	NO_2^-	NO_3^-	NH_3	SiO_2	P	TP	Fe^{2+}	Mn^{2+}	Zn^{2+}	Pb^{2+}
TS	1.0																						
TDS	0.4	1.0																					
TSS	0.1	-0.5	1.0																				
EC	0.4	1.0	-0.5	1.0																			
pH	-0.2	-0.2	0.4	-0.2	1.0																		
COD	0.3	0.2	0.0	0.2	0.8	1.0																	
HCO_3^-	0.5	1.0	-0.5	1.0	-0.3	0.1	1.0																
Cl^-	0.9	1.0	-0.5	1.0	-0.3	0.2	1.0	1.0															
SO_4^{2-}	0.4	0.9	-0.3	0.9	0.0	0.5	0.8	0.9	1.0														
Na^+	0.1	0.9	-0.5	0.9	0.1	0.3	0.9	0.9	0.9	1.0													
K^+	0.3	1.0	-0.4	1.0	-0.1	0.1	1.0	0.9	0.8	0.9	1.0												
Ca^{2+}	0.8	0.3	0.4	0.3	-0.4	0.1	0.3	0.5	0.4	0.0	0.2	1.0											
Mg^{2+}	0.8	0.9	-0.6	0.9	-0.6	0.1	0.9	0.9	0.8	0.7	0.8	0.5	1.0										
NO_2^-	0.0	-0.3	0.7	-0.4	0.9	-0.5	-0.3	-0.4	-0.4	-0.3	-0.1	0.3	-0.7	1.0									
NO_3^-	0.3	0.3	0.1	0.2	-0.3	-0.1	0.2	0.2	0.2	0.1	0.2	0.6	-0.7	0.4	1.0								
NH_3	0.5	0.9	-0.4	0.9	-0.1	0.3	0.8	0.9	0.9	0.8	0.8	0.4	0.7	-0.3	0.4	1.0							
SiO_2	-0.1	0.4	-0.1	0.5	-0.2	0.0	0.3	0.5	0.5	0.4	0.3	0.2	0.8	-0.1	0.2	0.6	1.0						
P	0.1	0.7	-0.7	0.7	-0.2	0.5	0.6	0.7	1	0.7	0.5	0.3	1.0	-1.0	0.5	0.7	0.2	1.0					
TP	0.9	0.8	0.0	0.8	-0.3	0.0	0.8	0.8	0.8	0.7	0.8	0.9	0.7	0.2	0.7	0.7	0.6	0.8	1.0				
Fe^{2+}	0.4	-0.1	0.7	-0.1	-0.6	-0.5	0.0	-0.1	-0.2	-0.4	-0.1	0.8	-0.4	1.0	0.9	-0.3	-0.2	0.0	0.6	1.0			
Mn^{2+}	0.5	0.0	0.5	0.1	-0.7	-0.6	0.1	0.2	0.1	-0.2	0.0	0.8	1.0	-1.0	0.9	0.1	0.1	0.5	0.7	1.0	1.0		
Zn^{2+}	-0.9	-0.5	-0.8	-0.5	-0.6	-0.3	0.4	-0.4	-0.6	-0.5	-0.7	-0.6	0.7	-0.6	-0.5	-0.6	-0.6	1.0	-0.7	-1.0	-1.0	1.0	
Pb^{2+}	-0.2	-0.7	0.6	-0.6	0.5	0.5	-0.7	-0.7	-0.3	-0.5	-0.7	0.0	-0.9	0.0	-0.3	-0.5	-0.2	-0.4	-0.7	0.0	0.0	-0.4	1.0

Table (38) Correlation coefficient matrix of physicochemical parameters during autumn season

	TS	TDS	TSS	EC	pH	COD	HCO_3^-	Cl^-	SO_4^{2-}	Na^+	K^+	Ca^{2+}	Mg^{2+}	NO_2^-	NO_3^-	NH_3	SiO_2	P	TP	Fe^{2+}	Mn^{2+}	Zn^{2+}	Pb^{2+}
TS	1.0																						
TDS	1.0	1.0																					
TSS	0.5	0.4	1.0																				
EC	1.0	1.0	0.4	1.0																			
pH	-0.5	-0.5	-0.1	-0.6	1.0																		
COD	-0.2	-0.1	-0.8	0.0	-0.2	1.0																	
HCO_3^-	1.0	1.0	0.4	1.0	-0.7	-0.1	1.0																
Cl^-	1.0	1.0	0.4	1.0	-0.5	-0.1	1.0	1.0															
SO_4^{2-}	0.8	0.9	0.3	0.9	-0.4	0.3	0.8	0.9	1.0														
Na^+	1.0	1.0	-0.4	1.0	-0.4	0.0	1.0	1.0	0.7	1.0													
K^+	1.0	1.0	0.4	1.0	-0.6	-0.3	1.0	1.0	0.9	1.0	1.0												
Ca^{2+}	0.8	0.9	-0.4	0.9	-0.3	0.7	0.4	0.9	0.8	-0.1	0.1	1.0											
Mg^{2+}	0.7	0.6	0.5	0.5	0.0	-0.7	0.8	0.6	0.4	0.7	0.6	-0.4	1.0										
NO_2^-	-0.3	-0.3	0.3	-0.3	0.9	0.0	-0.5	-0.2	0.1	-0.2	-0.4	0.3	0.1	1.0									
NO_3^-	0.0	0.0	-0.4	0.0	0.6	0.0	-0.1	0.0	0.1	0.5	-0.3	-0.3	0.3	0.5	1.0								
NH_3	-0.4	0.2	-1.0	0.7	-1.0	0.9	1.0	0.5	0.6	-0.9	0.9	0.5	-1.0	-1.0	-1.0	1.0							
SiO_2	0.3	0.3	-0.5	0.2	-0.4	-0.6	0.4	0.2	-0.1	0.4	0.5	-0.9	0.3	-0.7	0.6	1.0	1.0						
P	0.5	0.5	0.8	0.4	-0.2	-0.7	0.4	0.4	0	0.3	0.4	-0.1	0.8	-0.2	-0.2	-1.0	-0.2	1.0					
TP	0.9	0.9	0.7	0.8	-0.2	-0.4	0.8	0.9	0.8	0.8	0.8	-0.1	0.7	-0.1	0.1	-0.9	0.0	0.6	1.0				
Fe^{2+}	0.1	0.1	0.3	0.2	-0.6	0.2	0.2	0.1	0.0	-0.5	0.0	0.4	-0.4	-0.6	-1.0	1.0	-0.3	0.1	0.1	1.0			
Mn^{2+}	0.1	0.0	0.4	0.1	-0.5	0.1	0.1	0.1	-0.2	-0.6	-0.1	0.5	-0.3	-0.6	-1.0	1.0	-0.1	0.1	0.2	1.0	1.0		
Zn^{2+}	-0.2	-0.2	-0.3	-0.1	0.2	0.2	-0.1	-0.1	-0.1	-0.3	0.1	-1.0	-0.4	1.0	0.8	-1.0	1.0	-0.8	-0.4	-0.4	-0.2	1.0	
Pb^{2+}	-0.5	-0.5	-0.1	-0.6	0.3	-0.1	-0.6	-0.5	-0.5	-0.5	-0.7	-0.1	-0.1	0.0	0.2	-0.9	-0.5	0.3	-0.2	0.1	0.2	-0.8	1.0

Table(39) Correlation coefficient matrix of physicochemical parameters during winter season

	TS	TDS	TSS	EC	pH	COD	HCO_3^-	Cl^-	SO_4^{2-}	Na^+	K^+	Ca^{2+}	Mg^{2+}	NO_2^-	NO_3^-	NH_3	SiO_2	P	TP	Fe^{2+}	Mn^{2+}	Zn^{2+}	Pb^{2+}
TS	1.0																						
TDS	0.9	1.0																					
TSS	0.7	0.5	1.0																				
EC	0.9	1.0	0.6	1.0																			
pH	-0.2	-0.3	0.0	-0.2	1.0																		
COD	0.8	0.8	0.5	0.8	0.1	1.0																	
HCO_3^-	0.9	1.0	0.5	0.9	-0.4	0.7	1.0																
Cl^-	0.8	1.0	0.5	1.0	-0.3	0.9	1.0	1.0															
SO_4^{2-}	0.8	0.9	0.8	0.9	0.1	1.0	0.7	0.9	1.0														
Na^+	0.4	0.2	0.8	0.8	0.9	0.7	-0.8	0.3	1.0	1.0													
K^+	0.9	1.0	0.8	1.0	-0.4	0.7	1.0	1.0	0.8	-0.9	1.0												
Ca^{2+}	-1.0	1.0	-1.0	1.0	-1.0	-1.0	1.0	1.0	0.0	-1.0	1.0	1.0											
Mg^{2+}	0.7	0.6	0.5	0.6	-0.2	0.3	0.7	0.6	0.8	0.2	0.7	1.0	1.0										
NO_2^-	-0.1	0.3	0.1	0.4	0.3	0.6	0.1	0.3	0.5	0.5	0.2	0.0	0.0	1.0									
NO_3^-	0.2	0.3	-0.3	0.2	0.8	0.4	0.2	0.2	0.5	1.0	0.2	0.0	0.4	0.3	1.0								
NH_3	0.5	0.6	-0.3	0.6	-0.2	0.4	0.6	0.6	0.9	-0.2	0.8	0.0	0.2	0.0	0.6	1.0							
SiO_2	0.3	0.8	0.1	0.8	-0.5	1.0	0.7	0.8	1.0	1.0	0.7	0.0	0.7	0.8	-1.0	1.0	1.0						
P	0.9	0.9	0.7	1.0	-0.3	0.8	0.9	1.0	1	0.7	0.9	0.0	0.5	-0.1	0.0	0.3	1.0	1.0					
TP	-0.1	0.2	-0.5	0.2	-0.5	-0.1	0.2	0.2	0.9	-0.8	0.9	1.0	-0.5	0.1	-0.4	0.7	-1.0	-0.1	1.0				
Fe^{2+}	0.4	0.4	0.8	0.4	-0.7	0.4	0.4	0.5	1.0	0.0	0.3	0.0	-0.3	-0.8	-0.7	0.3	1.0	0.6	1.0	1.0			
Mn^{2+}	0.9	0.5	0.9	0.5	0.8	0.5	0.6	0.5	0.0	1.0	1.0	0.0	0.9	-0.6	0.0	1.0	0.0	0.7	-0.9		1.0		
Zn^{2+}	0.0	-0.6	0.2	-0.6	0.5	-0.6	-0.5	-0.6	-0.9	0.1	-0.5	0.0	-0.1	-0.7	-0.2	-0.5	-1.0	-0.9	-0.4	-0.6	-1.0	1.0	
Pb^{2+}	-0.6	-0.6	0.0	-0.5	0.7	-0.2	-0.8	-0.8	-0.1	1.0	-0.7	-1.0	-0.5	0.3	-0.1	-0.6	-0.5	-0.7	-0.5	-0.3	-0.4	0.3	1.0

Table (40) Correlation coefficient matrix of physicochemical parameters at station (I) during (2003-2004)

	TS	TDS	TSS	EC	pH	COD	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Na^+	K^+	Ca^{2+}	Mg^{2+}	NO_2^-	NO_3^-	NH_3	SiO_2^-	P	TP	Fe^{2+}	Mn^{2+}	Zn^{2+}	Pb^{2+}
TS	1.0																							
TDS	0.8	1.0																						
TSS	0.4	-0.2	1.0																					
EC	0.5	0.4	0.1	1.0																				
pH	0.5	0.3	0.6	-0.2	1.0																			
COD	0.4	0.7	-0.4	0.6	-0.2	1.0																		
CO_3^{2-}	-0.4	-0.5	0.0	-0.3	0.6	-0.4	1.0																	
HCO_3^-	0.5	0.8	-0.4	0.3	0.0	0.7	-0.7	1.0																
Cl^-	0.4	0.7	-0.4	0.5	-0.1	0.7	-0.6	0.9	1.0															
SO_4^{2-}	0.6	1.0	-0.3	0.7	0.4	1.0	-0.3	0.8	0.9	1.0														
Na^+	0.7	0.6	0.0	0.8	0.0	0.9	0.0	0.5	0.5	0.9	1.0													
K^+	-0.1	-0.1	0.0	-0.6	0.2	-0.1	-0.1	0.3	0.2	-0.1	-0.5	1.0												
Ca^{2+}	0.7	0.9	-0.3	0.3	0.4	0.8	-0.3	0.8	0.8	1.0	1.0	0.3	1.0											
Mg^{2+}	0.2	-0.1	0.4	-0.1	0.1	-0.2	0.3	-0.6	-0.7	-0.5	0.1	-0.7	-0.3	1.0										
NO_2^-	0.6	0.0	0.9	0.2	0.2	-0.2	-0.1	-0.2	-0.2	-0.2	0.2	0.1	0.0	0.4	1.0									
NO_3^-	0.7	-0.2	1.0	0.2	0.7	-0.4	0.0	-0.5	-0.3	-0.2	0.1	0.0	-0.1	0.5	1.0	1.0								
NH_3	0.2	0.4	-0.2	0.4	0.4	0.5	0.5	0.0	0.0	0.7	0.9	-0.4	0.8	0.2	-0.2	-0.1	1.0							
SiO_2^-	0.7	0.5	0.5	0.1	-0.1	0.6	-0.4	0.7	0.9	0.9	1.0	0.6	0.5	0.6	0.7	1.0	-0.5	1.0						
P	0.8	0.1	0.3	0.3	-0.6	-0.1	-0.8	0.4	0.5	-1	-1.0	1.0	0.0	-0.5	0.5	1.0	-0.7	1.0	1.0					
TP	0.0	0.1	-0.2	0.1	0.1	-0.2	-0.1	0.3	0.5	-0.3	-0.4	0.7	-0.1	-0.7	-0.2	0.9	-0.3	0.0	0.6	1.0				
Fe^{2+}	-0.4	-0.6	0.1	0.6	-1.0	0.1	0.3	-0.3	0.0	0.9	1.0	-0.8	-0.4	-0.8	0.1	-1.0	0.2	-0.6	-1.0	0.3	1.0			
Mn^{2+}	-0.9	-0.7	-1.0	0.9	-0.9	0.3	0.0	0.8	1.0	0.0	-1	0.0	1.0	-1.0	-1.0	0.0	1.0	0.0	-1.0	0.5	1.0	1.0		
Zn^{2+}	-0.8	-0.4	-0.4	-0.2	-0.9	0.1	-0.3	-0.1	-0.2	-0.4	-0.4	-0.7	-0.5	0.3	-0.4	-0.7	-0.4	-0.1	-0.3	-0.3	1.0	1.0	1.0	
Pb^{2+}	-0.3	-0.5	0.3	0.0	-0.1	-0.6	0.6	-0.8	-0.7	-0.6	-0.2	-0.6	-0.8	0.6	0.2	0.4	0.1	-0.6	0.0	0.0	0.1	-0.3	0.3	1.0

Table (41) Correlation coefficient matrix of physicochemical parameters at station (II) during (2003-2004)

	TS	TDS	TSS	EC	pH	COD	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Na^+	K^+	Ca^{2+}	Mg^{2+}	NO_2^-	NO_3^-	NH_3	SiO_2^-	P	TP	Fe^{2+}	Mn^{2+}	Zn^{2+}	Pb^{2+}
TS	1.0																							
TDS	0.6	1.0																						
TSS	0.2	-0.5	1.0																					
EC	-0.3	-0.7	0.5	1.0																				
PH	-0.2	0.3	-0.6	-0.7	1.0																			
COD	0.5	-0.3	0.6	0.3	-0.5	1.0																		
CO_3^{2-}	-0.8	-0.3	-0.2	0.1	0.4	-0.7	1.0																	
HCO_3^-	0.7	0.6	0.0	-0.3	-0.1	0.1	-0.7	1.0																
Cl^-	0.1	0.1	-0.3	0.2	-0.1	-0.1	-0.5	0.5	1.0															
SO_4^{2-}	-0.6	-0.2	-0.4	-0.3	0.9	-0.4	0.9	-0.6	-0.1	1.0														
Na^+	-0.3	-0.3	-0.1	-0.4	0.8	-0.1	0.2	-0.2	-0.2	0.9	1.0													
K^+	-0.4	-0.4	-0.1	0.2	0.2	-0.2	0.0	0.2	0.6	0.8	0.8	1.0												
Ca^{2+}	0.7	0.9	-0.3	-0.8	0.6	0.0	-0.4	0.7	0.4	0.2	0.1	-0.7	1.0											
Mg^{2+}	0.6	0.7	0.2	-0.5	0.1	0.7	0.2	-0.1	-0.8	-0.7	-0.9	-1.0	1.0	1.0										
NO_2^-	-0.2	-0.1	-0.4	0.0	0.5	0.4	0.4	-0.5	-0.3	0.4	0.2	-0.1	0.0	0.3	1.0									
NO_3^-	-0.1	-0.1	0.0	0.6	-0.7	0.2	0.0	-0.4	0.1	-0.9	-0.9	-0.5	-0.4	0.9	-0.3	1.0								
NH_3	-0.6	-0.2	0.0	0.1	-0.2	-0.4	0.8	-0.8	-0.6	0.0	-0.3	-0.6	-0.4	0.8	0.1	0.6	1.0							
SiO_2^-	0.5	0.0	0.1	0.2	-0.7	0.7	-0.9	0.5	0.6	-0.6	-0.4	-0.2	0.0	-0.5	-0.3	0.9	-0.7	1.0						
P	0.2	0.0	0.6	0.2	-0.6	-0.4	-0.7	0.8	0.7	-1	-0.4	0.4	-0.2	-0.5	-0.8	0.0	-0.7	0.6	1.0					
TP	0.5	0.3	0.0	0.2	-0.2	0.3	-0.4	0.7	0.6	-0.4	-0.4	0.4	0.4	-0.2	0.1	-0.3	-0.7	0.3	0.4	1.0				
Fe^{2+}	0.4	0.2	0.8	0.4	-1.0	-0.7	0.0	1.0	0.1	-1.0	-0.9	0.1	0.0	0.0	-0.8	-0.6	-0.8	0.0	0.6	0.7	1.0			
Mn^{2+}	0.3	0.0	0.8	0.2	-0.9	0.2	-0.6	0.6	0.2	-1.0	-0.9	-0.6	-0.5	0.4	-0.6	1.0	0.5	0.8	1.0	-0.4	1.0	1.0		
Zn^{2+}	0.0	0.4	-0.6	-0.1	0.2	-0.4	-0.3	0.5	0.9	0.1	0.0	0.6	0.0	-0.9	-0.3	-0.1	-0.5	0.3	0.7	0.5	-0.3	0.8	1.0	
Pb^{2+}	0.0	-0.4	0.5	0.0	-0.1	0.2	0.0	0.1	-0.4	0.0	0.4	0.2	-0.6	-0.3	-0.2	-0.5	-0.2	-0.1	0.4	0.0	0.5	0.4	-0.5	1.0

Table (42) Correlation coefficient matrix of physicochemical parameters at station (III) during (2003-2004)

	TS	TDS	TSS	EC	pH	COD	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Na^+	K^+	Ca^{2+}	Mg^{2+}	NO_2^-	NO_3^-	NH_3	SiO_2^-	P	TP	Fe^{2+}	Mn^{2+}	Zn^{2+}	Pb^{2+}
TS	1.0																							
TDS	0.3	1.0																						
TSS	0.8	0.3	1.0																					
EC	0.8	0.5	0.7	1.0																				
pH	-0.7	-0.6	-0.8	-0.8	1.0																			
COD	0.5	0.1	0.8	0.7	-0.5	1.0																		
CO_3^{2-}	-0.4	0.1	-0.7	0.0	0.3	-0.4	1.0																	
HCO_3^-	0.5	0.7	0.4	0.3	-0.6	-0.1	-0.3	1.0																
Cl^-	0.8	0.1	0.1	0.4	-0.5	0.0	-0.2	0.6	1.0															
SO_4^{2-}	0.8	-0.3	0.7	0.7	-0.3	0.8	0.0	-0.1	0.1	1.0														
Na^+	-0.9	-0.2	-0.6	-0.7	0.6	-0.3	0.3	-0.5	-0.6	-0.7	1.0													
K^+	0.2	-0.8	-0.1	-0.2	0.0	-0.3	-0.3	0.5	0.7	0.5	-0.3	1.0												
Ca^{2+}	0.6	0.1	0.3	0.1	-0.3	-0.3	-0.5	0.7	0.4	0.1	-0.7	0.6	1.0											
Mg^{2+}	-0.9	0.7	-0.1	0.0	-0.2	0.0	0.4	0.0	-0.7	-0.9	0.8	-1.0	-0.5	1.0										
NO_2^-	-0.7	0.1	-0.8	0.1	-0.5	-0.8	0.8	-0.5	-0.9	-1.0	0.7	-0.6	-0.7	0.7	1.0									
NO_3^-	1.0	0.1	0.8	0.9	-0.7	1.0	-0.2	0.1	-0.2	1.0	-1.0	0.7	0.5	0.0	-1.0	1.0								
NH_3	-0.3	0.5	-0.6	0.1	0.0	-0.4	0.9	-0.1	0.0	0.0	0.2	-0.5	-0.4	0.7	0.6	-0.3	1.0							
SiO_2^-	0.1	-0.2	0.4	-0.4	0.4	0.0	-0.7	0.1	-0.1	-0.7	-0.2	0.0	0.5	-0.2	-0.9	-0.3	-0.7	1.0						
P	0.5	0.3	0.5	0.4	-0.7	0.4	-0.7	0.8	1.0	0	-0.6	0.8	0.9	-0.7	-1.0	0.3	-0.5	0.1	1.0					
TP	-0.2	0.3	-0.8	0.1	0.4	-0.6	0.7	0.2	0.1	-0.5	-0.2	-0.2	0.1	0.2	0.0	0.9	0.7	-0.2	-0.7	1.0				
Fe^{2+}	0.6	0.9	0.2	0.6	-0.6	-0.1	0.3	0.9	0.9	0.3	-0.6	0.9	0.6	0.4	1.0	0.4	0.6	-0.6	1.0	0.4	1.0			
Mn^{2+}	0.4	0.3	-0.2	0.1	-0.1	-0.7	0.4	0.9	1.0	1.0	-0.6	0.5	0.8	-1.0	0.0	-1.0	0.7	-0.3	1.0	0.8	1.0	1.0		
Zn^{2+}	1.0	-1.0	-0.5	0.0	0.4	-0.4	0.0	0.9	0.8	0.8	-0.8	1.0	0.6	-1.0	0.0	0.0	-1.0	0.0	0.0	0.0	1.0	0.0	1.0	
Pb^{2+}	0.4	-0.3	0.8	0.5	-0.3	0.9	-0.4	-0.3	0.0	0.8	-0.2	0.1	-0.3	-0.4	-0.2	1.0	-0.6	0.0	0.3	-0.7	-0.2	-0.8	0.2	1.0

Table (43) Correlation coefficient matrix of physicochemical parameters at station (IV) during (2003-2004)

	TS	TDS	TSS	EC	pH	COD	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Na^+	K^+	Ca^{2+}	Mg^{2+}	NO_2^-	NO_3^-	NH_3	SiO_2^-	P	TP	Fe^{2+}	Mn^{2+}	Zn^{2+}	Pb^{2+}
TS	1.0																							
TDS	0.9	1.0																						
TSS	0.5	0.1	1.0																					
EC	-0.2	-0.1	-0.4	1.0																				
pH	0.0	-0.1	0.2	-0.9	1.0																			
COD	-0.1	0.2	-0.5	0.7	-0.8	1.0																		
CO_3^{2-}	-0.4	-0.5	0.1	-0.5	0.8	-0.9	1.0																	
HCO_3^-	0.6	0.9	0.2	-0.4	0.3	-0.3	0.0	1.0																
Cl^-	0.5	0.6	0.0	0.1	-0.3	0.6	-0.7	0.3	1.0															
SO_4^{2-}	0.8	0.9	0.4	-0.3	0.1	0.2	-0.5	0.7	0.8	1.0														
Na^+	1.0	1.0	-0.4	-1.0	1.0	-0.8	0.0	1.0	0.9	1.0	1.0													
K^+	0.2	0.2	0.0	-0.5	0.3	0.2	-0.2	0.2	0.7	0.7	0.9	1.0												
Ca^{2+}	1.0	0.9	0.5	-0.8	0.7	-0.9	0.8	0.9	-0.9	-1.0	0.0	1.0	1.0											
Mg^{2+}	0.3	0.3	0.1	0.4	-0.3	-0.2	0.1	0.4	-0.5	-0.1	1.0	-0.9	0.0	1.0										
NO_2^-	-0.5	-0.4	-0.3	0.4	-0.6	0.6	-0.5	-0.7	0.2	-0.3	-1.0	0.1	-1.0	-0.3	1.0									
NO_3^-	-0.4	-0.4	-0.1	0.5	-0.5	0.2	-0.1	-0.4	-0.3	-0.6	-0.5	-0.4	0.3	0.3	-0.5	1.0								
NH_3	-0.4	-0.5	0.1	-0.6	0.7	-0.9	0.9	0.3	-0.8	-0.7	0.0	-0.5	0.7	0.8	-0.5	-0.2	1.0							
SiO_2^-	0.2	0.2	0.1	0.3	-0.6	0.7	-0.7	-0.2	0.7	0.5	0.0	0.2	-0.9	-0.1	0.5	-0.1	-0.8	1.0						
P	0.1	0.0	0.1	-0.3	0.3	0.3	-0.2	-0.1	0.8	0.0	-0.8	0.9	0.4	-0.9	0.0	-0.1	-0.6	0.2	1.0					
TP	0.3	0.2	0.3	-0.5	0.6	-0.2	0.1	0.3	0.7	0.6	0.3	1.0	1.0	-0.8	-0.4	-0.2	-0.4	-0.9	0.9	1.0				
Fe^{2+}	0.4	0.2	0.6	0.2	-0.3	0.2	-0.5	0.0	0.6	0.5	-0.4	0.3	0.0	-0.3	-0.1	0.3	-0.8	0.3	0.5	0.8	1.0			
Mn^{2+}	0.3	0.1	0.7	0.1	-0.2	0.1	-0.5	-0.1	0.5	0.3	-0.5	0.5	0.1	-0.4	-0.1	0.4	-0.8	0.2	0.6	0.6	1.0	1.0		
Zn^{2+}	1.0	1.0	1.0	-1.0	-1.0	-1.0	0.0	1.0	-1.0	-1.0	0.0	-1.0	0.0	1.0	0.0	1.0	0.0	0.0	-1.0	-1.0	-1.0	-1.0	1.0	
Pb^{2+}	0.6	0.5	0.2	0.4	-0.6	0.2	-0.4	0.4	0.0	0.2	0.5	-0.4	0.2	0.8	-0.4	0.5	-0.3	0.2	-0.5	-0.3	0.4	0.3	1.0	1.0

Table (44) The physicochemical parameters (mg/l) of ground water in Kalyoubia Governorate (2003-2004) compared to Greater Cairo Sites (1982) and standard specifications

Parameter / Sites	TDS mg/l	pH	Heavy Metals				anions				Cations			
			Fe^{2+} mg/l	Mn^{2+} mg/l	Pb^{2+} mg/l	Zn^{2+} mg/l	SO_4^{2-} mg/l	Cl^- mg/l	HCO_3^- mg/l	CO_3^- mg/l	Ca^{2+} mg/l	Mg^{2+} mg/l	Na^+ mg/l	K^+ mg/l
This work	783.6	7.8	2.1	3.5	0.1	0.4	80.3	129.9	567.1	3.1	83.5	110.2	54.7	9.3
Qaluib	1178.7	8.0	5.5	1.5	0.1	0.2	174.3	127.3	530.7	0.0	79.7	49.0	180.0	4.0
Bahtim	290.3	8.2	1.3	0.4	0.1	0.6	33.0	45.0	128.0	7.5	9.3	16.0	53.7	5.0
Kobry Al-Koba	3531.7	7.6	0.5	0.0	0.2	3.1	595.0	1034.7	134.7	n.d	306.0	60.0	579.3	43.0
Old Egypt	1254.7	8.2	1.6	0.6	0.3	0.5	281.0	111.7	447.3	24.0	38.3	53.7	159.0	147.7
Dar-El Salam	1881.3	7.7	7.7	2.6	0.3	0.4	563.0	458.7	21.0	0.0	217.7	149.0	141.3	39.3
El-Maadi	1199.3	8.0	5.2	0.1	0.2	0.1	321.0	241.3	280.7	2.0	55.7	58.0	227.7	19.7
El-Masara	1879.3	7.2	5.0	0.3	0.3	0.6	412.3	702.7	124.0	n.d	165.7	36.0	382.3	42.7
Helwan	2592.3	7.4	2.0	0.1	0.2	0.7	289.7	1270.7	169.7	n.d	263.0	149.7	416.0	30.3
Embaba	637.7	7.2	5.5	1.2	0.2	0.7	19.0	144.3	303.3	n.d	34.7	58.3	60.3	11.0
Cairo Universty	757.0	7.8	3.2	0.3	0.2	0.7	18.3	83.3	474.0	n.d	47.3	38.3	102.7	11.7
Al-Badrashen	6228.0	7.6	0.6	0.2	0.3	3.0	877.3	3142.7	36.5	4.0	232.7	510.0	1600.3	65.0
Specification														
Egyptian standard	1200	6.5-9.5	1	0.5	0.05	5	400	500	n.d	n.d	200	150	200	n.d
WHO	1200	6.5-8.5	0.3	0.1	0.05	5	400	250	n.d	n.d	n.d	n.d	200	n.d
Europian Standard	n.d	6.5-8.5	0.3	0.05	0.05	3	25	25	n.d	n.d	n.d	n.d	150-175	12
US Standard	500	6.5-8.5	0.3	0.05	0.05	5	250	250	n.d	n.d	n.d	n.d	n.d	n.d

All parmerers presented are the annual average of each site
n.d = Not detected

Table (45) The physico-chemical parameters (mg/l) of ground water in Kalyoubia Governorate (2003-2004) before and after traditional treatment in 4-stations compared to standard specifications

Parameter / Sites	TDS mg/l	pH	Heavy Metals				anions				Cations			
			Fe^{2+} mg/l	Mn^{2+} mg/l	Pb^{2+} mg/l	Zn^{2+} mg/l	SO_4^{2-} mg/l	Cl^- mg/l	HCO_3^- mg/l	CO_3^- mg/l	Ca^{2+} mg/l	Mg^{2+} mg/l	Na^+ mg/l	K^+ mg/l
(a)	783.6	7.8	2.1	3.5	0.1	0.4	80.3	129.9	567.1	3.1	83.5	110.2	54.7	9.3
(b)	782.6	7.9	0.6	0.4	0.1	0.5	84.5	118.5	549.3	3.4	76.0	115.3	55.7	9.0
Specification														
Egyptian standard	1200	6.5-9.5	1	0.5	0.05	5	400	500	n.d	n.d	200	150	200	n.d
WHO	1200	6.5-8.5	0.3	0.1	0.05	5	400	250	n.d	n.d	n.d	n.d	200	n.d
Europian Standard	n.d.	6.5-8.5	0.3	0.05	0.05	3	25	25	n.d	n.d	n.d	n.d	150-175	12
US Standard	500	6.5-8.5	0.3	0.05	0.05	5	250	250	n.d	n.d	n.d	n.d	n.d	n.d

All parameters presented are the annual average of each site
n.d = Not detected
a = before traditional treatment
b = after traditional treatment

3.B. The 2nd section

The second part is concerned with the characterization of the activated carbon derived from rice husk then activated by chemical treatment using H_3PO_4. Also, it includes the data for treatment of iron and manganese ground water in station I (winter season) using this carbon by adsorption technique. In this concern, various factors influencing the process such as: contact time, carbon mass and batch factor were studied in batch mode. Further more, mini column tests were adapted for iron removal from ground water under investigation.

The physicochemical properties of RH-57 carbon are presented in table 46. The pore size distribution by DFT is presented in fig.36 and it shows a significant amount of micropores with the apparent bimodal distribution of pores in the microporous region with two maxima at 1.1 and 1.7 nm respectively. The DFT method is applicable for the entire ranges of pore sizes accessible by the adsorptive molecule (N_2), which makes this technique very attractive compared to the well-known commonly used BET method [102]. The surface area and pore volume of RH- 57 carbon are 419 m^2/g and 0.213 ml/g respectively.

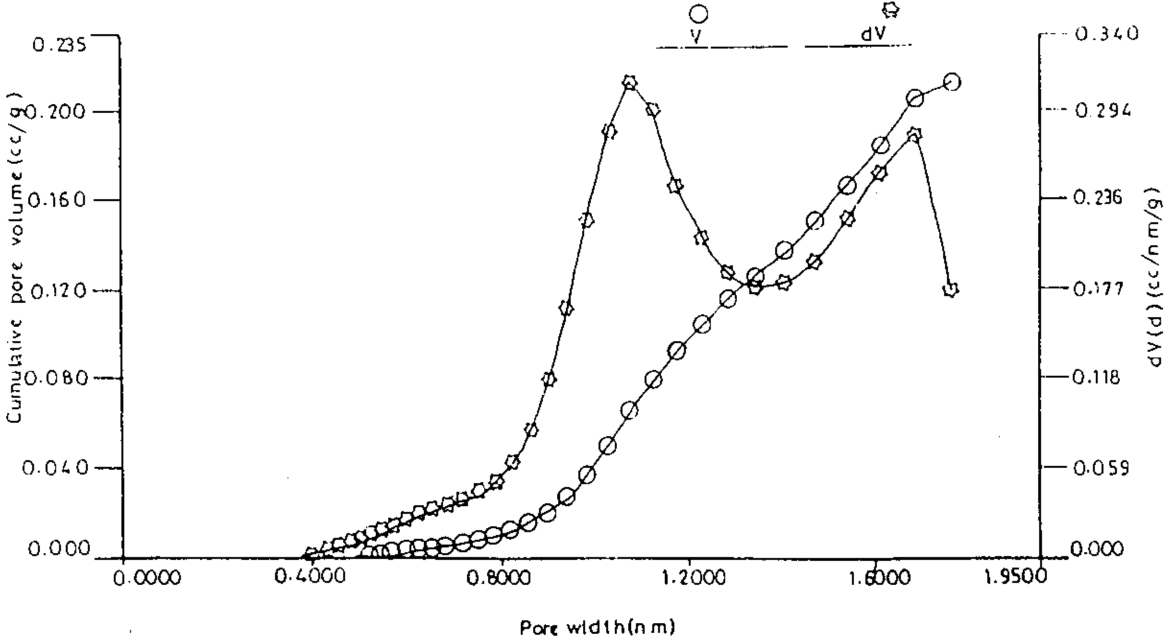


Fig. (36) the pore size distribution by DFT of RH-57 carbon

Table (46) The physicochemical parameters of RH-57 carbon

parameter	Value
S_{BET} (surface area, m^2/g)	419
V_p (total pore volume, cm^3/g)	0.213
d (pore width, nm)	1.076
ash content (%)	31
pH	5
Apparent density, g/cm^3	0.25
Packed density, g/cm^3	0.33
Grain size	0.6 mm

3.B.1. Adsorption experiments:-

3.B.1.1. Effect of agitation time

Effect of agitation time: The time –profile of adsorption of Fe^{2-} and Mn^{2-} ions onto RH- 57 at room temperature (25 ±1°C) is presented in fig.37.

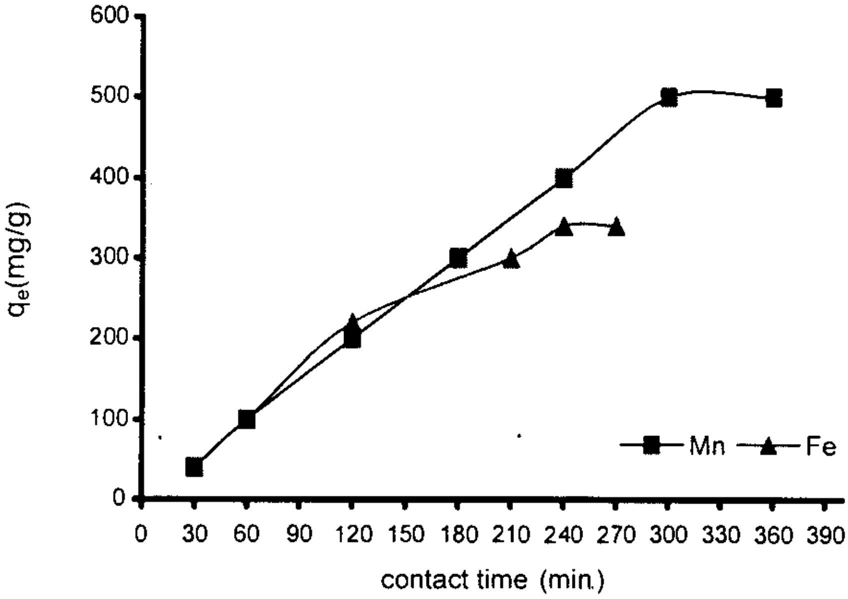


Fig (37) The sorbnt phase concentration of RH- 57 as a function of time for Fe^{2+} and Mn^{2+} removal

As the agitation time increases, cation removal also increases initially, but then gradually approaches a more or less constant value, denoting attainment of an equilibrium. Obviously, the equilibrium was attained after shaking for about 4 h in case of $Fe^{2+}$and 5 h in case of Mn^{2+}, beyond which there is no further increase in the adsorption. As shown in fig (37) , the uptake amount increased from 100 to 400 mg/g in case of Fe^{2+} and from 40 to 500 mg/g in case of Mn^{2+} to reach the equilibrium. A shaking time of 5 h employed for all the equilibrium adsorption studies was enough to ensure that adsorption equilibrium was reached in each case.

3.B.1.2. Effect of sorbent mass

Fig (38). shows that increasing the amount of carbon increases the percent removal (R%) to reach 100 % from 1L solution containing 2 or 3 mg/l of Fe^{2+} or Mn^{2+} respectively (sample of station I in winter) attained constant removal after a particular carbon amount (optimum dosage).

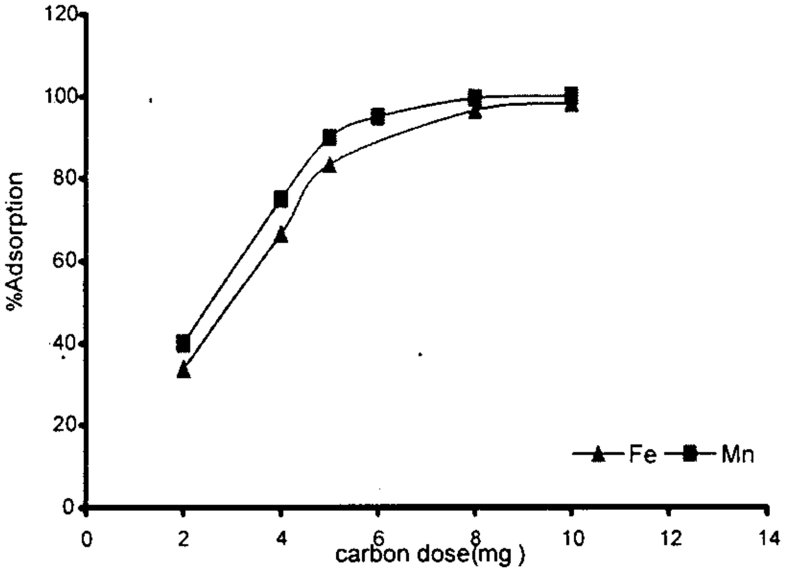


Fig (38) Effect of Carbon dose onthe adsorption of Fe^{2+} and Mn^{2+}

The minimum adsorbent dosage of 8 mg was required for complete removal of either Fe^{2+} or Mn^{2+} after contact period of 5 hr.

3.B.1.3. Effect of batch factor

The ratio of volume solution containing 2 or 3 mg/l of Fe^{2+} or Mn^{2+} respectively (sample of station I in winter) to the amount of RH-57 affects the efficiency of adsorption process. the results are presented in fig.39

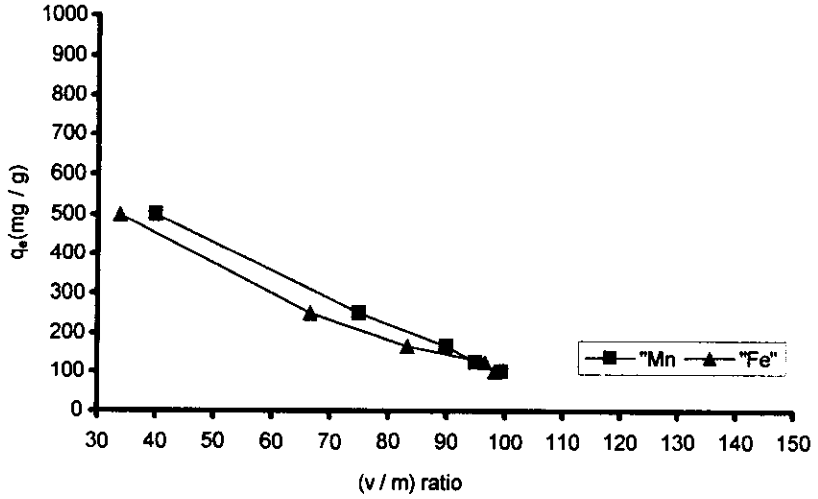


Fig.(39) Effect of volume/ mass ratio on the uptake of Fe^{2+} and Mn^{2+} using RH-57

3.B.2. Sorption dynamics:

3.B.2.1. Rate constant study

The kinetics of sorption of selected metal ions under investigation on carbon were studied on the basis of Lagergren equation [103]:

$$\text{Log}\,(q_e - q) = \log q_e - (K_{ad}/\,2.303)\,t \qquad \text{.................................(3.4)}$$

Where q (mg/g) is the amount of metal ions sorbed at time t, q_e (mg/g) is the amount sorbed at equilibrium and K_{ad} is the equilibrium rate constant of sorption. The straight line plots (fig.40) of log (q_e -q) vs. t for Fe^{2+} and Mn^{2+} ions indicate the validity of equation – and the adsorption process follows first order rate kinetics. The K_{ad} values of metal ions were calculated from the slopes of these plots and the results are given in table (47).

Table (47) Sorption kinetic parameters for Fe^{2+} and Mn^{2+} using RH-57 carbon

Metal ions	K_{ad} (min.$^{-1}$)	K_p (mg.g^{-1}.min$^{-0.5}$)	Ionic radius (A)
Fe^{2+}	0.0097	0.0322	0.76
Mn^{2+}	0.00306	0.021	0.80

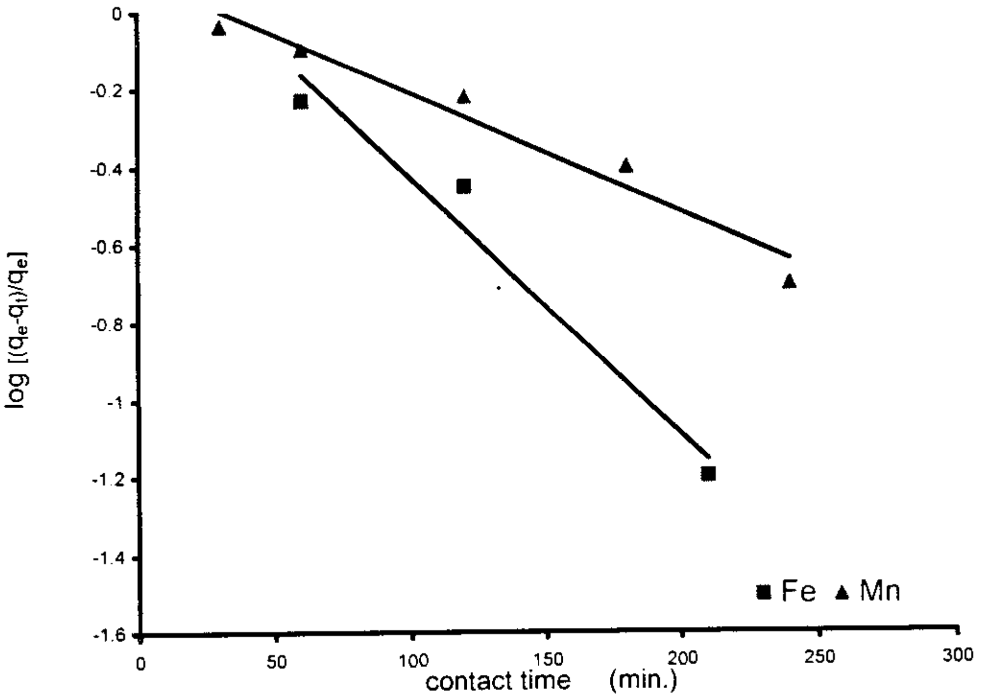


Fig (40)The sorbnt phase concentration of RH-57 (mg /g) as a function of time (min.) for Fe^{2+} and Mn^{2+} removal

3.B.2.2. Diffusion rate constant study:

The sorption of metal ions from aqueous media by carbon can be described by three consecutive steps: (i) the transport of sorbate from bulk solution to the outer surface of the sorbent by molecular diffusion, known as external diffusion, (ii) internal diffusion i.e., the transport of sorbate from the particle surface into interior sites, and (iii) the sorption of the solute particles from the active sites into the interior surfaces of the pores. The overall rate of the sorption process will be controlled by the slowest step; i.e., the rate –limiting step. The nature of the rate –limiting step in batch system can be determined from the properties of the solute and sorbent. Rates of sorption are usually measured by determining the change in the concentration of sorbate with sorbent as a function of time. Liberalization of the data is obtained by plotting the amount sorbed per unit weight of sorbent (q_e) vs. $t^{1/2}$, as shown in fig.(41) , as described by the following equation:

$$q_e = K_p\, t^{1/2} \qquad \text{...(3.5)}$$

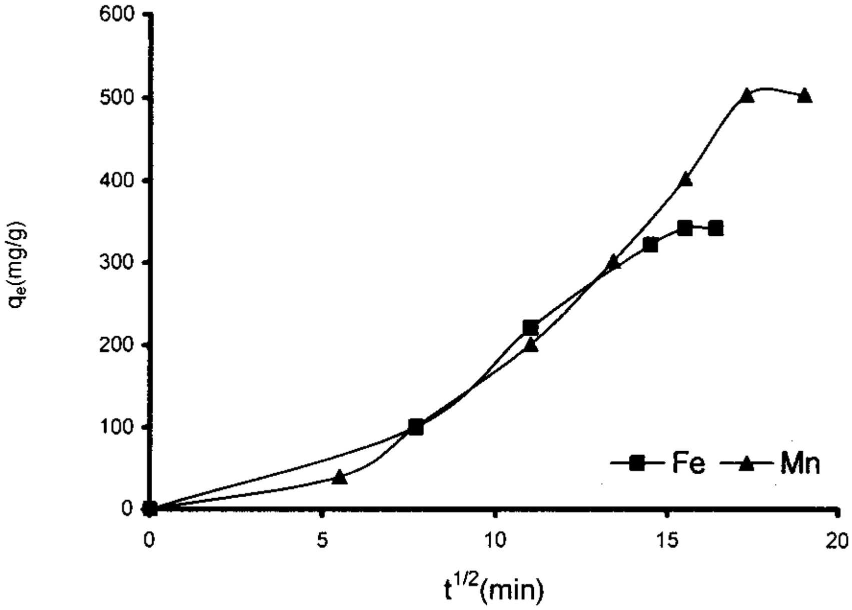


Fig. (41) The sorbent phase concentration of RH -57 carbon (mg/g) as a function of time (h) for Fe^{2+} and Mn^{2+} removal

Where K_p is the intraparticle diffusion rate constant. The sorption rates for intraparticle diffusion, K_p were calculated from the slopes of the linear portions of the respective plots with units of mg.g-1 min.-0.5 (not the true reaction rate, but relative rates which are useful for comparative purposes) are given in table (10). The two plots have the same general features, initial curved portion followed by linear portion and plateau. The initial curve portions are attributed to the boundary layer diffusion effects. While the linear portions are a result of the intraparticle diffusion effects [100] and the plateau is attributed to the equilibrium. An extrapolation of the linear the plateau is attributed to the equilibrium. An extrapolation of the linear portion of the plots back to the time$^{0.5}$ axis provides intercepts which are proportional to the extent of boundary layer thickness. The larger the intercept, the greater is the boundary layer effect [100], and it follows the sequence: $Mn^{2+} > Fe^{2-}$. This follows the same order of ionic radius as shown in table (47).

3.B.3. Adsorption isotherms:

Adsorption data for a wide range of adsorbate concentrations are most conveniently described by adsorption isotherm such as the Langmuir or Freundlich isotherms, which relate adsorption density qe (metal uptake per unit weight of adsorbent) to equilibrium adsorbate concentration in the bulk liquid phase C_e.

The Langmuir isotherm is valid for monolayer adsorption onto a surface containing a finite number of identical sites. The model assumes uniform energies of adsorption onto the surface and no transmigration of adsorbate in the plane of the surface. The Langmuir isotherm is represented by the following equation:

$$\frac{C_e}{q_e} = \frac{1}{bq^0} + \frac{c_e}{q^0} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3.6)$$

where c_e is the equilibrium concentration (mg/l), q_e is the amount adsorbed at equilibrium time (mg/g) and q^0 and b are Langmuir constants related to adsorption capacity and energy of adsorption, respectively [104], which can be calculated from the $1/q_e$ vs. $1/c_e$ plot . The linearized Langmuir plot is shown in fig. (42a). The Langmuir parameters were found to be (357 mg/g and 625 mg/g for q°) for iron and for manganese, respectively. Comparison of values of Fe^{2+} & Mn^{2-} adsorption onto RH-57 carbon with literature data indicated that adsorption capacity of RH-57 carbon is much greater than the other adsorbents. The Freundlich adsorption isotherm was also applied for the adsorption of Fe^{2+} & Mn^{2+} ions onto RH-57 carbon. The Freundlich equation is presented as [83]:

$q_e = k_f c_e^{1/n}$ ……………………………………(3.7)

Rearranging Eq. (3.7) in a logarithmic form gives:

$\text{Log } q_e = \log k_f + 1/n \log c_e$ ………(3.8)

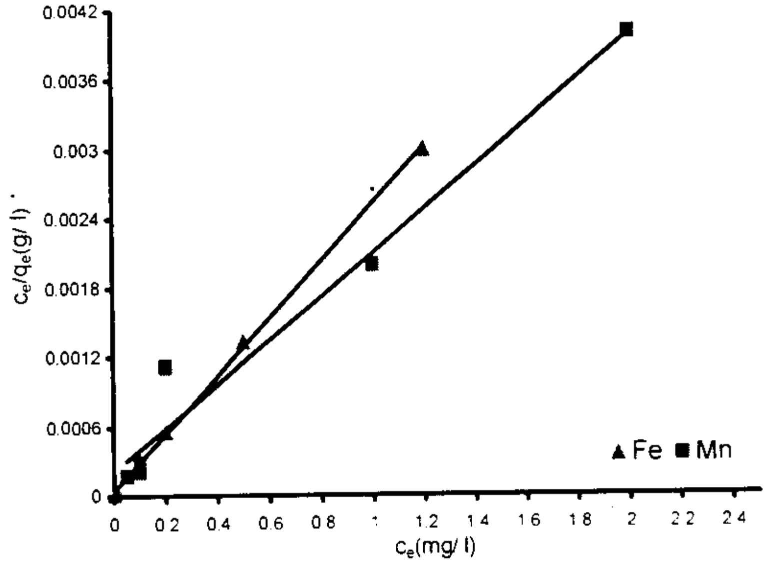


Fig.(42-a) Langmuir plot of Fe^{2+} and Mn^{2+} using RH- 57 carbon

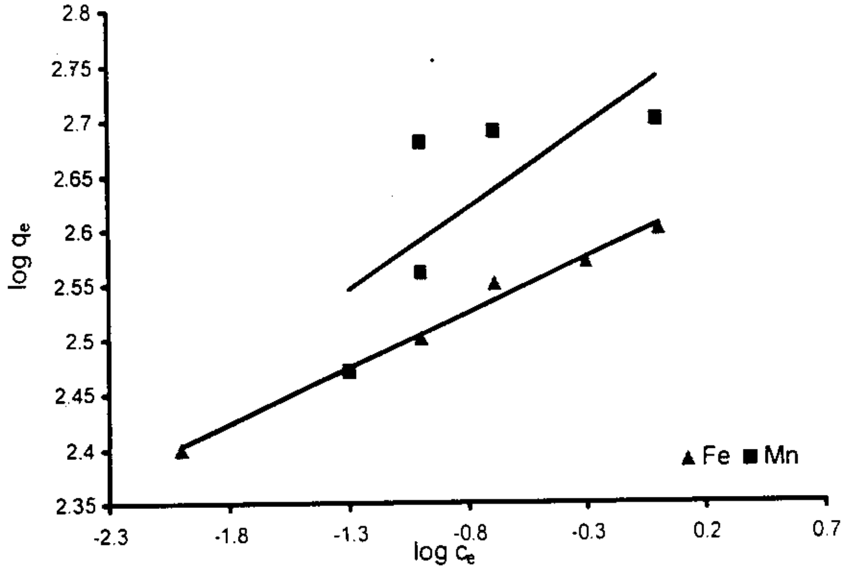


Fig.(42-b) Freundlich plot of Fe^{2+} and Mn^{2+} using RH-57 carbon

Hence, a plot of log q_e vs. log c_e enables the constants k_f and exponent n to be determined. The constants are listed in table (48). Although the correlation coefficients are greater than 95 %, they do not correlate the data as well as the Langmuir isotherm, which has consistently higher correlation coefficients as seen in table (48).

Table (48) Langmuir and Freundlich constants for Fe^{2+} and Mn^{2+} sorption using RH-57 carbon

Adsorption system	Langmuir q^o mg/g	 b l/mg	 r	Freundlich k_f	 n	 r
Fe^{2+}	357	0.0014	98.8	178	25.4	99.7
Mn^{2+}	625	0.009	90.4	352	10.8	73.1

3.B.1.4. Possible working mechanisms

Both iron and manganese ions surrounded by an electric double layer due to electrostatic interactions [102]. Based on the theory of the diffuse double layer, the thickness of the double layer is compressed by an increase in the ionic strength of the solution [103-104]. Such compression helps the carbon particles and metal ions to approach each other more closely. The attractive forces (such as van der Waals' forces) then become significant, leading to an increased uptake of the metal ion.

Besides, two major types of chemical bondings can be responsible for the adsorption of the two metal ions onto the RH-57 carbon [105]. The covalent bonding results from the sharing of the free electron pairs between the surface oxygen atom and the metal ion or the formation of an $O\ldots M^{n+}$ bonding. The hydrogen bonding between surface oxygen atom and the hydrogen atom of the hydrated metal ions.

The FTIR was used to evaluate the mechanism involved. Fig(43) shows FTIR spectra of RH-57 carbon (original), with Mn^{2+} ions and with

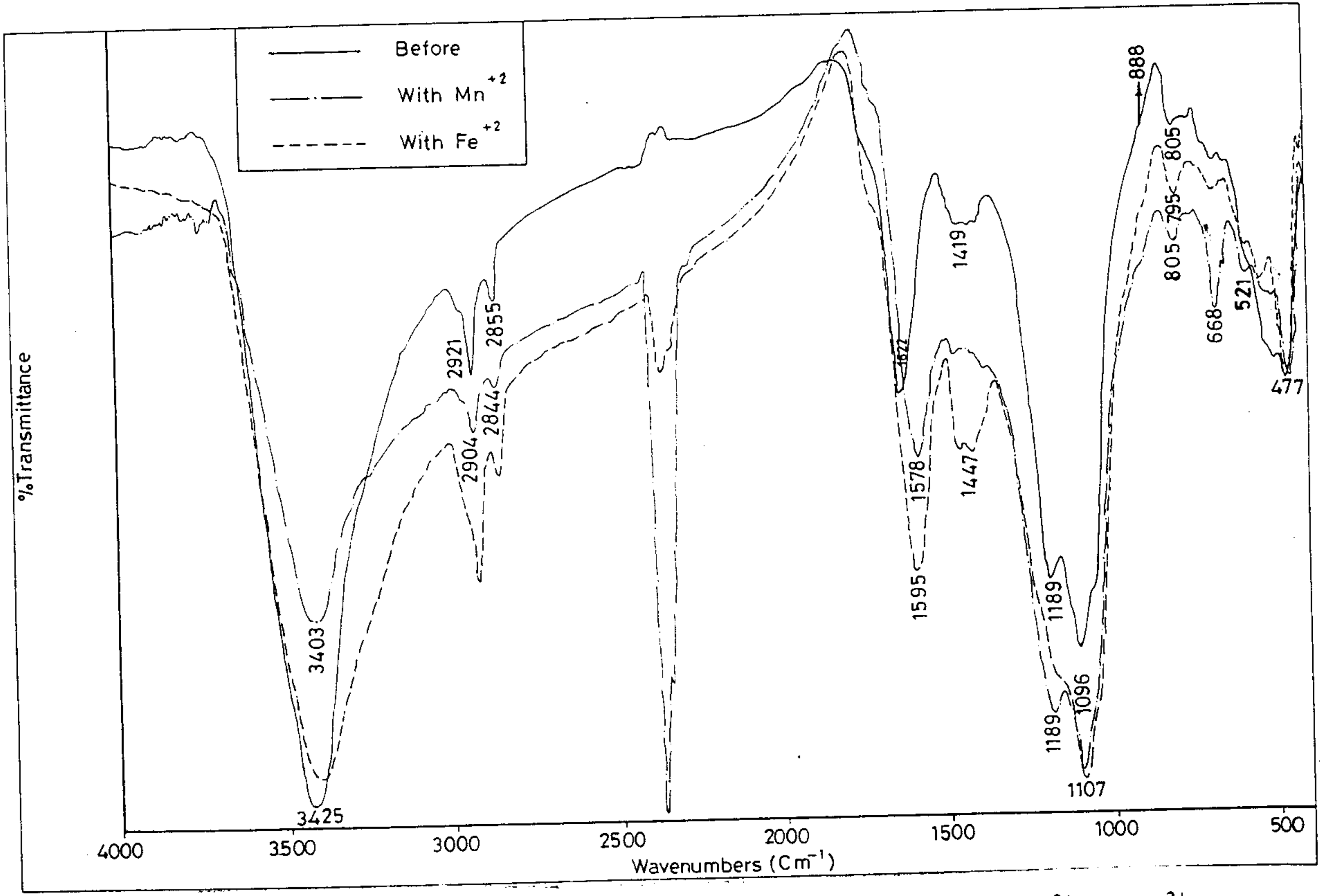


Fig. (43) IR-spectra of RH-S7 carbon before and after uptake of Fe^{2+} or Mn^{2+}

Fe^{2+} ions. All the spectra showed the broad bands at 3425 and 1189 cm^{-1} which may be due to hydrogen bonded –OH and P=O. Thus, the surface OH groups probably interact with water molecules adsorbed on the carbon surface from the environment [106]. The high silica content appears in FTIR spectra, the presence of free SiO_2 is indicated by the presence of a bond at 477 cm^{-1}. The very strong peak at 1100 cm^{-1} is due to the presence Si-O asymmetric stretching bond. The bond at about 800 cm^{-1} is considered to be the bonding between C and Si or the overlapping of the Si-OH vibrations [107-109]. Also, the intensity of the peak near 3425 cm^{-1}, due to the Si-OH stretching, decreased after the metal ions uptake.

The ion–exchange reaction on the silica surface is accomplished through the substitution of protons of the surface silanol groups by the metal ions from solution, as follows [110]:

$$M^{n+} + x\,(\equiv SiOH) \leftrightarrow M(\equiv SiO)_x^{(n-x)+} + xH^+ \quad \ldots\ldots\ldots\ldots\ldots\ldots(3.9)$$

Where the symbol (≡) distinguishes surface complexes from soluble complexes, M^{n+} = metal ion with n+ charge, (≡ SiOH) = silanol group on the SiO_2 surface and xH^+ = number of protons released. The cation–exchange mechanism is expected to occur with the two metal ions as the sorbent contains large amounts of silica (> 95%) in the ash content (31%).

Also, since electrostatic attraction was possible between negatively charged adsorbent surface and positively charged metal ion species, it seems that some electrostatic forces were involved in the adsorption process [111].

According to surface chemistry theory, RH-57 carbon particles and metal ions are uptake in by the interaction between the metal ion and the surface groups. The band in the region of 1260 cm^{-1} has been observed for RH-57 carbon and shifted to lower wave numbers with high intensity after metal ion removal. This band is due to stretching vibration of Si– CH_3 bond, which are polarized by oxygen atoms near one of the carbon atoms

[112]or due to highly conjugated carbonyl groups [113]. A new peak at 521 cm^{-1}appears in the spectrum of RH-57 carbon with Mn^{2+} which corresponds to Mn–O stretching mode. The peak at 1189 cm^{-1} appears as shoulder after Fe^{2+} uptake with high intensity and the peak at 1096 cm^{-1} is shifted to higher wave number (1107 cm^{-1}) with high intensity after Mn^{2+} uptake. Similar trend was also observed when oil shale was treated by sodium and potassium hydroxide [114] due to metal carbonation and metal salt vibrational modes.

It is suggested that the observed apparent high intensity of the FTIR bands may be attributed to the effect of metal ion uptake on the carbon surface as it accomplished with reducing the surface area of RH-57 carbon.

3.B.1.5. Dynamic studies

Fig.(44) shows that the column filled with RH-57 carbon can be regenerated and recycled at least five times without affecting the sorption capacity of RH-57 carbon for Fe^{2+} ions (with an initial concentration C° = 2 ppm). Experimentally, similar service time of 50 min. ($t_{1/2}$) at 50% breakthrough was obtained even after five times of successive regeneration using 0.5 ml of 1% $KMnO_4$ (0.06 M concentration). The adsorption capacity was determined at this high flow rate (1 ml/min.) using column experiments data by integrating the upper part of concentration versus throughput volume; fig. (45).

The adsorption capacity at $C_e/C°$ = 50% or $Q_{0.5}$) was 1 mg Fe^{2+} per 1 gram sorbent. The total integrated amount of Fe^{2+} adsorbate was divided by the weight of the sorbent placed in the column to yield the adsorption capacity of – mg/g . Since this capacity was quite lower than the Langmuir monolayer capacity (0.357 g/g) presented in table (48), it may be inferred that full saturation of the sorbent active sites was not achieved due to the

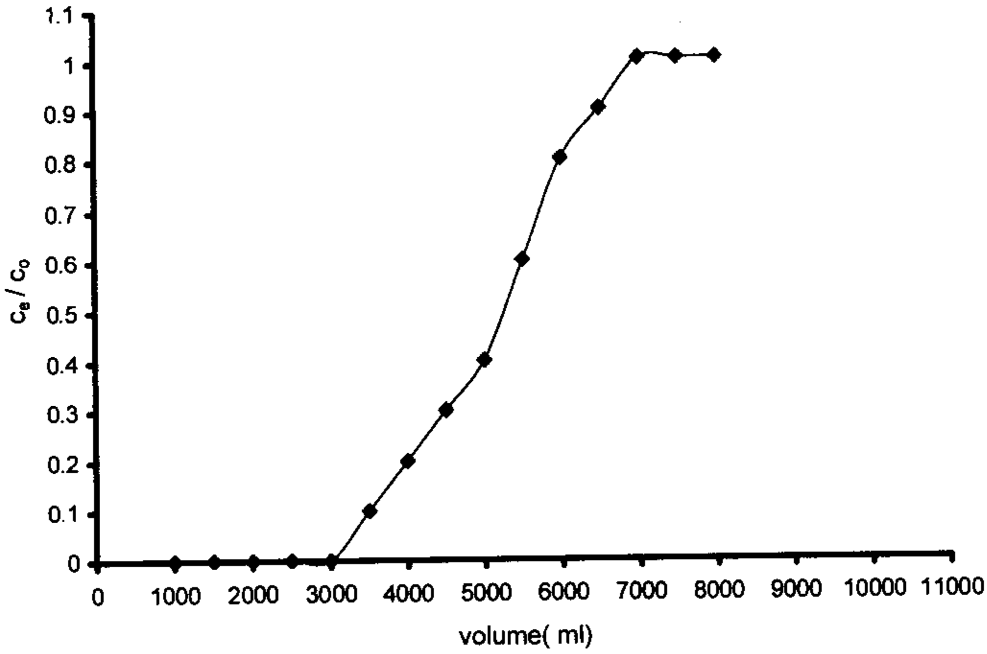


Fig. (44) c_e/c_o versus volume of pure water in iron removal by RH-57 carbon

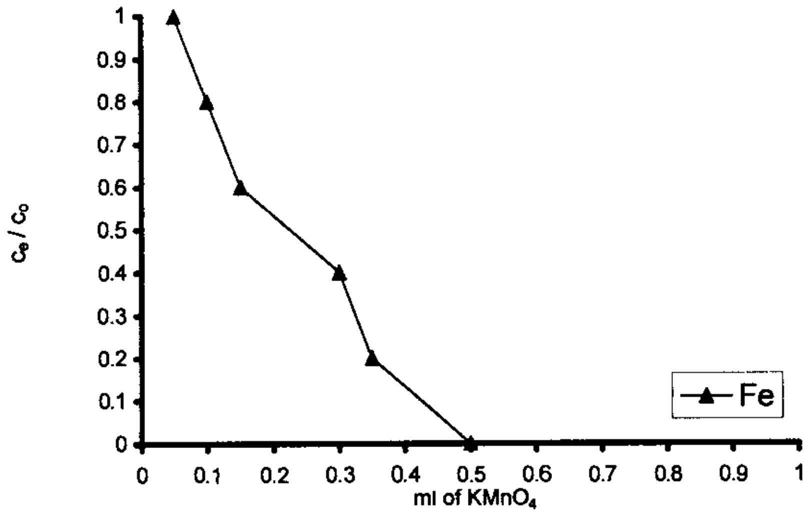


Fig. (45) Elution curve of RH-57 carbon using 0.06 $KMnO_4$

limited time of equilibrium due to the high flow rate used under dynamic column conditions. Another factor causing the discrepancy may be the partial invalidity of the Langmuir assumption, i.e., envisaging monoenergetic adsorption on a homogeneous surface, on the inhomogeneous surface of the RH-57 carbon as a composite sorbent. As shown in fig.(45), the column needs only 0.5 ml of 0.06 M $KMnO_4$ for each cycle and no weight loss per cycle should be considered. Such results are suitable for household filters which can be used in the sparsely populated countryside, where public water supplies are usually far away. According to the results, the treated water quality remained good and no significant external radiation dose was caused to the residents.

As shown in table (49) the treatment with RH-57 carbon completely removed iron and manganese.

As shown in table (50) the treatment with RH-57 carbon (more than 99 %) was more efficient than traditional treatment (70 %).

Table (49) The physico-chemical parameters in (mg/l) of ground water of station I (winter season) before and after treatment using RH-57 carbon compared to standard specifications

Parameter	TDS mg/l	pH	Heavy Metals				anions				Cations			
			Fe^{2+} mg/l	Mn^{2+} mg/l	Pb^{2+} mg/l	Zn^{2+} mg/l	SO_4^{2-} Mg/l	Cl^- mg/l	HCO_3^- mg/l	CO_3^- mg/l	Ca^{2+} mg/l	Mg^{2+} mg/l	Na^+ mg/l	K^+ mg/l
(a)	783	7.5	2	3	0.1	0.5	80.3	129.9	567.1	3.1	83.5	110.2	54.7	9.3
(b)	750	7.4	0	0	n.d	n.d	77	125	550	3.4	76	115.3	55.7	9
Specification														
Egyptian standard	1200	6.5-9.5	1	0.5	0.05	5	400	500	n.d	n.d	200	150	200	n.d
WHO	1200	6.5-8.5	0.3	0.1	0.05	5	400	250	n.d	n.d	n.d	n.d	200	n.d
Europian Standard	n.d	6.5-8.5	0.3	0.05	0.05	3	25	25	n.d	n.d	n.d	n.d	150-175	12
US Standard	500	6.5-8.5	0.3	0.05	0.05	5	250	250	n.d	n.d	n.d	n.d	n.d	n.d

a = before treatment
b = after treatment using RH-57
n.d = not detected

Table (50) Comparison between traditional treatment and adsorption treatment using RH-57 carbon compared to standard specifications

Parameter	TDS mg/l	pH	Heavy Metals				anions				Cations			
			Fe^{2+} mg/l	Mn^{2+} mg/l	Pb^{2+} mg/l	Zn^{2+} mg/l	SO_4^{2-} Mg/l	Cl^- mg/l	HCO_3^- mg/l	CO_3^- mg/l	Ca^{2+} mg/l	Mg^{2+} mg/l	Na^+ mg/l	K^+ mg/l
(a)	782.6	7.9	0.6	0.4	0.1	0.5	84.5	118.5	549.3	3.4	76	115.3	55.7	9
(b)	750	7.4	0	0	n.d	n.d	77	125	550	3.4	76	115.3	55.7	9
Specification														
Egyptian standard	1200	6.5-9.5	1	0.5	0.05	5	400	500	n.d	n.d	200	150	200	n.d
WHO	1200	6.5-8.5	0.3	0.1	0.05	5	400	250	n.d	n.d	n.d	n.d	200	n.d
Europian Standard	n.d	6.5-8.5	0.3	0.05	0.05	3	25	25	n.d	n.d	n.d	n.d	150-175	12
US Standard	500	6.5-8.5	0.3	0.05	0.05	5	250	250	n.d	n.d	n.d	n.d	n.d	n.d

a = after traditional treatment
b = after treatment using RH-57 carbon
n.d = not detected