EFFECT OF THE DIFFERENT ENVIRONMENT FACTORS THE GROUNDWATER CHARACTERISTICS AT EL–SADAT CITY - EGYPT

[1]

Nora A. M. Abdel-Rahman[1]; Taha A. M. Abdel Razek[1] and Yahia R. Gedamy[2]
1) Institute of Environmental Studies and Research, Ain Shams University, Cairo, Egypt 2) Desert Research Center, Cairo, Egypt

ABSTRACT

This work aims to evaluate the pollution hazards of surface and groundwater at El–Sadat City, Egypt. Forty-five water samples were collected from the surface water bodies (El–Nasery canal and the oxidation ponds) and groundwater samples at the study area. The chemical composition of the water resources at El-Sadat city was outlined through out determination of pH, EC, TDS, major cations and anions. The pollution of the collected water samples was evaluated based on determination of minor elements, trace and soluble heavy metals as well as biological and bacteriological pollutants

Results revealed that all surface water samples (El–Nasery canal) and the majority of the groundwater samples (93%) in the study area are fresh water, while the rest of the groundwater samples (7%) are brackish water. All surface water and majority of the groundwater samples (90%) are suitable for drinking as they have a salinity as well as nitrite, nitrate, phosphate and trace constituents less than the permissible limits as well as their low contents from faecal Coliforms. The rest of the groundwater samples (10%) are unsuitable for drinking as they have nitrite, nitrate, phosphate and trace constituents higher than the permissible limits as well as their high contents from faecal Coliforms.

Key words: Water chemistry, water pollution, water evaluation, El-Sadat City.

INTRODUCTION

El–Sadat City is considered as one of the biggest and important industrial city in Egypt. It has been established more than four decades ago at about 80km northwest of Cairo along the Cairo – Alexandria desert road. The study area is bounded by latitudes 30^0 18´& 30^0 30´N and longitudes 30^0 30´& 30^0 50´ E. The total area of El-Sadat city is about $500km^2$ (Fig.1).

The groundwater is considered the main source of water for drinking, agriculture and industrial activities. Great attention is being paid to the aquifers in this area because its high water content and good quality due its mainly recharged from the Nile Delta fresh aquifer.

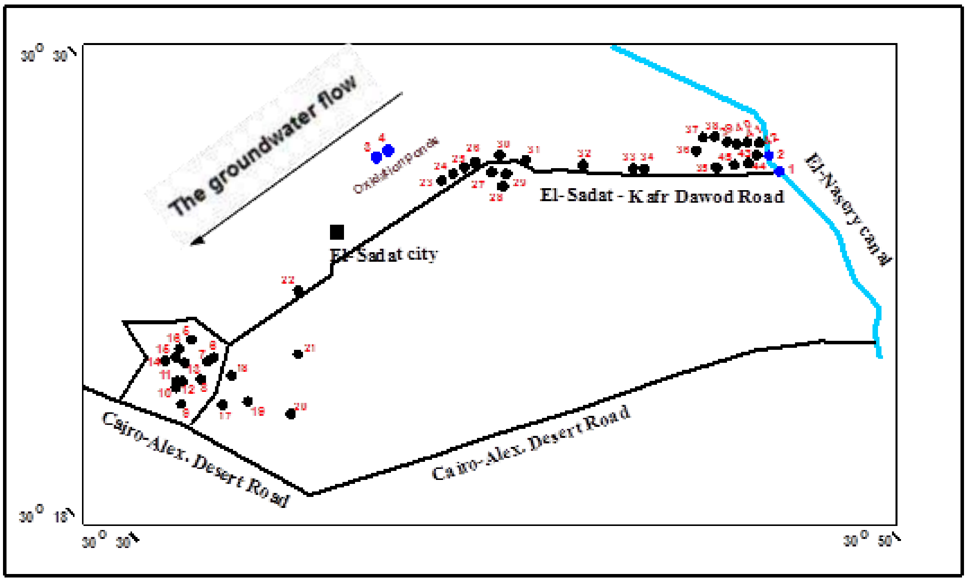

Fig. (1): The water samples sites map

There are more than 94 factories of chemicals and metallurgy industries at El–Sadat city (El–Tahawy *et al*.,2006). Also, it was noticed that the nearest fresh drinking water source for El–Sadat city is El–Nasery canal that is located at 25km east of El–Sadat city (Badway *et al.,* 2016).

There are two wastewater ponds (oxidation ponds) at El–Sadat city are used for collection domestic, agricultural and industrial waste materials via a network of pipelines. Wastewater contains many polluted materials which may be penetrated down to the Pleistocene aquifer and negatively affect the water quality. From the climatic view, the area under investigation belong to the semi-arid region, where it is characterized by hot and dry weather in the summer and mild to cold weather in winter.

Great attention paid to its aquifer due to its high water content and good quality as it mainly recharged from the Nile Delta fresh aquifer. The water resources in the study area divided into surface water and groundwater; the surface water represented by El–Nasery canal, which extended from northeast to north the study area. While the groundwater represented by the Pleistocene aquifer, which is the main groundwater reservoir in El–Sadat city and almost all the productive wells tap this aquifer to yield the water needed for domestic, agricultural and industrial activities. Minor feeding also comes from rainfall and surface infiltration.

The aim of this study is to identify the chemical and microbial pollution of surface water (El–Nasery canal) and groundwater samples at El–Sadat city as well as their suitability for the different purposes.

MATERIALS and METHODS

A total number of forty–five (45) water samples were collected from El–Sadat city during 2017 and their locations was determined in situ using a GPS instrument model (Magellan Nave 5000 Pro), four surface water samples representing both El–Nasery canal and the oxidation ponds as well as forty-one samples representing the aquifer groundwater in the study area. These water samples were collected and brought back to the lab and kept in refrigerator for analyses.

The collected water samples were divided into five parts to determine five kinds of analyses. The first kind is the measurement of EC, pH and major cations (Na^+, K^+, Ca^{2+} and Mg^{2+}) & anions (Cl^-, CO_3^{2-}, HCO_3^- and SO_4^{2-}) as well as SiO2 according to Rainwater and Thatcher (1960). The second kind includes the measurement of minor constituents (NH_3,NO_2^-, NO_3^-, PO_4^{3-} and B) according to Fishman and Friedman (1985).The third kind of analyses can be done by acidifying the collected samples in situ by adding drops of HNO_3 acid for the measurement of trace elements and soluble heavy metals (Al, Fe, Zn, Mn, Cu, Ni, Cd, Pb, Cr, Co and Ba) using Inductive coupled plasma – Mass spectroscopy, ICP -MS) according to APHA, 1989. The fourth kind is the measurement of the biological oxygen demands (BOD) and chemical oxygen demands (COD) as well as total organic carbon (TOC) according to APHA, 1989. The fifth kind is the measurement of microbial contamination that performed within 24 hours of collection the water samples from the field using standard Multiple Tube Fermentation Technique for the determination of the Most Probable Number (MPN) index using double and single strength Bromo – Cresol Purple MacConkey medium while, for detection E. Coli and Salmonella sp., a yellow collar colony on filter membrane at 44^0 C was produced. For differentiation the different species of the enteric bacteria, subculturing colonies on Triple Sugar Iron (TSI) were done for the contaminated water samples according to APHA, 1989.

RESULTS AND DISCUSSION

3.I- Chemical characteristics of the surface water and groundwater samples in the study area: The chemical characteristics of the surface water and groundwater in the study area were investigated through the discussion of the water salinity and hypothetical salts.

3.I.1-Water salinity: The total dissolved solids (TDS) are a measure of total mass ions dissolved in water. Different methods used for water classification corresponding to its salinity values.

According to Chebotarev (1955), the natural water is classified under three main categories of total salinity as follows; fresh water < 1500mg/l, brackish water 1500 – 5000mg/l and saline water > 5000 mg/l.

The TDS values for surface water samples (El–Nasery canal) range from 265 – 283mg/l and vary between 4000 – 4863 mg/l for drainage water (oxidation ponds), while for groundwater samples, the TDS values vary between 241 (well No. 33) to 2098 mg /l (well No. 15), Table (1) and Fig. (2).Based on Chebotarev classification, it is clear that the majority of the groundwater samples (93%) in the study area belong to fresh zone and the rest of the sample (7%) belong to the brackish zone.

The groundwater samples that located in the fresh zone may be affected by the seepage from El-Nasery canal, while that located in the brackish zone may be affected by the agricultural and industrial activities.

3.I.2-Hypothetical Salt Combination: Hypothetically, the ions of the strong acids (Cl^- and SO_4^{2-}) form chemical combinations with alkalis (Na^+ and K^+) and the rest of the acid radical's combing with the alkaline earth's (Ca^{2+} and Mg^{2+}). If the cations of alkalis and alkaline earth's are in surplus in the water, they will combine with weak acids (HCO_3^-). The combination between major anions and cations reveals the formation of one group of hypothetical salt combination for both rain water and Nile River water, and three groups of hypothetical salts combinations for surface water and aquifer groundwater samples (Table 2).

Table (1): The concentration of the major constituents in the surface water and groundwater samples at the study area as mg/l (ppm)

Serial No.	Sample No.	pH	EC (us/cm)	TDS (mg/l)	Soluble cations as ppm				Soluble anions as ppm				SiO_2 (mg/l)
					Ca^{2+}	Mg^{2+}	Na^+	K^+	CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	
Surface water samples													
El-Nasery Canal													
1	34	7.11	462	265	45.5	10.3	31.5	5.08	-	121.4	40.4	72.0	0
2	36	7.10	474	283	36.7	14.8	36.6	5.47	-	74.4	47.5	104.7	0
Drainage water samples (Oxidation ponds)													
3	13	7.01	7410	4863	790.6	72.0	884.5	53.95	-	210.5	2797.8	158.9	0.8817
4	14	4.40	5590	4000	776.4	80.4	507.4	53.17	-	28.7	2010.6	557.5	6.554
Groundwater samples													
5	1	7.24	1210	727	68.7	29.5	141.2	5.47	-	104.3	194.3	235.8	2.940
6	2	7.09	1955	1134	90.5	32.1	280.1	8.21	-	137.9	٢٢٩,٣	425.1	3.046
7	3	7.19	2340	1462	114.0	41.6	324.1	7.82	-	69.6	366.0	573.5	2.968
8	4	7.12	526	335	37.5	4.5	67.2	5.30	-	45.8	52.8	145.1	2.841
9	5	7.47	482	275	36.7	8.9	49.7	3.91	-	111.7	67.4	52.4	3.031
10	6	7.13	1599	946	133.1	35.35	143.5	8.21	-	101.3	317.7	257.9	2.990
11	7	7.10	1943	1186	114.0	29.7	254.4	9.38	-	99.5	357.4	371.3	2.997
12	8	7.13	2140	1069	197.8	21.8	218.0	10.16	-	109.2	458.2	321.3	3.015
13	9	7.33	549	315	39.9	8.0	60.9	7.43	-	121.4	84.8	53.3	2.736
14	10	7.37	453	269	36.5	3.6	53.4	3.13	-	92.7	51.8	74.4	2.661
15	11	7.00	3450	2098	220.6	72.1	397.4	10.95	-	103.1	648.9	696.9	2.779

Cont. table (1): The concentration of the major constituents in the surface water and groundwater samples at the study area as mg/l(ppm)

Serial No.	Sample No.	pH	EC (us/cm)	TDS (mg/l)	Soluble cations as ppm				Soluble anions as ppm				SiO_2 (mg/l)
					Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}	
Groundwater samples													
16	12	7.00	3090	1916	183.8	58.0	385.0	8.99	-	67.1	250.2	726.7	3.107
17	15	7.00	1310	836	83.8	36.2	132.5	7.04	-	36.6	118.4	440.0	3.614
18	16	7.60	502	299	45.7	13.9	٣٥,٢	2.74	-	83.6	45.4	114.3	3.117
19	17	7.56	558	349	57.1	6.9	47.6	3.13	-	51.9	52.5	155.6	3.366
20	18	7.60	432	245	32.5	13.1	35.4	3.13	-	82.4	28.3	91.3	2.660
21	19	7.38	752	455	58.5	17.8	69.5	4.69	-	89.1	87.9	172.0	3.474
22	20	7.43	558	331	46.5	16.2	41.2	5.47	-	81.1	660.	115.3	1.141
23	21	7.25	1001	599	84.0	25.5	81.6	6.65	-	106.8	138.7	208.9	3.64
24	22	7.26	1171	699	121.6	13.9	99.4	7.36	-	115.9	204.3	194.5	3.27
25	23	7.42	720	435	65.1	13.1	63.7	5.86	-	88.5	102.5	140.2	3.318
26	24	7.12	2500	1584	125.9	40.5	٣٤٩,٦	7.36	-	135.4	94.3	966.04	3.753
27	25	7.18	1362	799	87.0	26.4	١٦٠,١	5.86	-	94.6	167.0	353.0	3.321
28	26	7.25	578	347	51.5	24.3	25.5	5.30	-	52.6	64.9	148.9	4.070
29	27	7.15	1216	758	100.6	24.4	110.2	6.25	-	81.8	123.4	352.5	3.354
30	28	7.24	1929	1229	110.2	37.6	241.7	7.43	-	125.7	165.6	603.3	4.324
31	29	7.33	641	387	67.7	16.3	34.5	3.91	-	81.8	57.1	166.7	3.304
32	30	6.65	1130	725	101.8	27.5	86.9	7.04	-	34.2	87.9	396.3	3.222
33	31	7.40	412	241	36.1	7.3	37.3	3.91	-	91.5	42.6	68.2	3.040
34	32	7.19	2370	1162	201.6	52.4	209.8	8.21	-	87.9	346.5	299.9	3.476
35	33	7.15	336	187	37.5	7.5	17.9	3.91	-	94.6	39.7	33.1	3.694
36	35	7.13	339	196	30.3	10.9	20.0	5.30	-	73.8	34.0	58.6	1.243
37	37	7.09	700	354	67.5	20.4	40.7	6.65	-	123.2	57.4	161.4	2.740
38	38	7.01	1171	703	100.0	28.3	92.3	6.25	-	61.0	108.5	367.4	3.093
39	39	7.70	900	579	109.6	14.2	49.9	7.04	-	23.8	77.7	308.4	2.873
40	40	7.41	1425	403	92.0	21.5	177.3	7.43	-	108.0	125.2	429.9	2.644
41	41	7.25	610	342	63.5	14.5	36.6	5.87	-	145.2	137.8	11.0	3.066
42	42	7.11	1054	621	108.6	16.5	81.4	8.60	-	192.8	128.4	180.6	2.861
43	43	7.05	1342	839	148.3	19.0	97.3	8.99	-	71.4	165.6	364.1	2.574
44	44	7.13	1162	701	106.6	30.2	83.7	7.43	-	130.0	135.8	272.3	2.984
45	45	7.31	651	387	74.85	18.1	35.4	4.69	-	114.1	74.1	122.5	3.446

Table (2): Hypothetical salts combinations of surface water and groundwater samples in the study area

Assemblages	Hypothetical salts combinations	%
Rain water		
I	NaCl, Na_2SO_4, $NaHCO_3$, $Mg(HCO_3)_2$ and $Ca(HCO_3)_2$	100
Nile River		
II	NaCl, Na2SO4, $MgSO_4$, $Mg(HCO_3)_2$ and Ca $(HCO_3)_2$	100
El–Nasery canal		
III	NaCl, Na_2SO_4, $MgSO_4$, $CaSO_4$ and $Ca(HCO_3)_2$	100
Drainage water samples (oxidation ponds)		
IV	NaCl, $MgCl_2$,, $CaCl_2$, $CaSO_4$ and $Ca(HCO_3)_2$	100
Groundwater samples		
III	NaCl, Na_2SO_4, $MgSO_4$, $CaSO_4$ and $Ca(HCO_3)_2$	68
II	NaCl, Na_2SO_4, $MgSO_4$,$Mg(HCO_3)_2$ and $Ca(HCO_3)_2$	5
IV	NaCl, $MgCl_2$, $CaCl_2$, $CaSO_4$ and $Ca(HCO_3)_2$	7
V	NaCl, $MgCl_2$, $MgSO_4$, $CaSO_4$ and $Ca(HCO_3)_2$	20

As shown in table (2), the presence of the hypothetical salts assembles (II and III) in 73% of the groundwater samples in the study area indicates that the majority of the groundwater samples in the study area are affected by El-Nasery canal water, i.e., there are seepage from the canal water to the groundwater. On the other hand, the rest of the groundwater samples (27%) have the assemblages (IV and V), which means that some groundwater samples in the study area are affected by the oxidation ponds and the effluents of the industrial factories as well as the return flow after irrigation. In addition, the presence of the hypothetical salts assembles (II and III) indicates that the leaching and the dissolution process for groundwater from the aquifer matrices., while the presence of hypothetical salts (IV and V) indicates the seepage of the drainage water from the oxidation ponds to the groundwater.

3.2-Water pollution: Pollution of water is discussed on the basis of determining the inorganic, biological and microbial pollutants analyses regarding to the recommended level of contamination, according to Egyptian Higher Committee for Water (1997) and WHO (2011).

Water pollution is a main cause of deaths and diseases worldwide. It is considered the world's biggest health risk, threaten not only humans, but also myriad other plants and animals that rely on water to live. The rapid extension of the industrial development countries was accompanied of pollution, especially due to wastewater discharged from factories.

3.2.1-Chemical inorganic pollutants

3.2.1.1-Trace elements and soluble heavy metals contamination: The concentration of some trace and soluble heavy metals are illustrated in table (3).

The obtained data show high variability among the measured trace elements, where some of them are less than safe limits for all the water samples, while the other show higher concentrations more than the permissible limits in some of the water samples.

It is noticed that all surface water samples (El–Nasery canal) have Al, Cr, Cu, Mn, Ni, Pb, Zn, B, Cd, Cu and Ba concentrations less than the permissible limits for contamination. On the other hand, all groundwater samples have Al, Cu, Ni, Pb, B, Cd, Cu and Ba concentrations less than the permissible limits for contamination. For Cr, Fe, Mn and Zn, the data showed that the concentrations less than the permissible limts were 98, 61, 88 and 68 %, respectively.

3.2.1.2- Nitrogen compounds: This form of pollutants includes the study the concentration of nitrogen compounds (NH_3, NO_2^-, NO_3^- and total N forms) and PO_4^{3-} (Table 4).

The nitrogen compounds play an important role in many processes that takes place in the natural waters. Nitrogen is also one of the basic compounds of protein, so it can enter surface water in sewage and industrial wastewater from the breakdown of proteins and other nitrogenous compounds. Nitrogen fertilizers are used extensively in agriculture and the excess over crop requirements is most leached into drainage water.

3.2.1.2.1- Ammonium content (NH_3): The concentration of NH_3 in El-Nasery canal and the oxidation ponds varies between 3.5 – 4.2 and 15.4 – 63.0mg/l, respectively. While the groundwater samples at the study area contain NH_3 lies between 2.8mg/l (well No.10) and 6.3mg/l (well No.11) with an average of 3.6mg/l. It noticed that both El-Nasery canal water samples and groundwater samples in the study area have NH_3 concentrations more than the permissible limit (0.5mg/l) due to the excess using of nitrogen fertilizers in the study area for the growing crops and seepage from the oxidation ponds.

Table (3): The concentration of some trace elements (ppm) in the surface water and groundwater samples at the study area

Serial No.	Sample No.	Al	Cr	Cu	Fe	Mn	Ni	Pb	Zn	B	Cd	Co	Ba
Surface water samples													
El – Nasery canal													
1	34	0.1385	0.0070	0.0152	1.292	0.0765	0.0007	0.0028	0.0265	ND	ND	0.0011	0.0692
2	36	0.1372	0.0079	0.0214	1.369	0.0856	0.0003	0.0029	0.0265	ND	ND	0.0012	0.0992
Drainage water samples (oxidation ponds)													
3	13	0.0761	ND	0.0081	0.1203	0.1411	0.0028	0.0030	0.0805	0.6660	0.0001	0.0022	0.1802
4	14	0.3636	0.0063	0.0601	1.1360	0.2581	0.0282	0.0172	0.1145	0.1868	0.0022	0.0062	0.7027
Groundwater samples													
5	1	ND	0.0017	0.0212	0.0093	0.0014	ND	0.0063	0.4297	ND	ND	0.0008	0.0638
6	2	ND	0.142	0.0071	ND	ND	ND	0.0028	0.0020	ND	ND	0.0008	0.0476
7	3	ND	0.0179	0.0104	0.0245	ND	ND	0.0025	0.0011	0.0438	ND	0.0006	0.0619
8	4	ND	0.0036	0.2350	0.0398	0.0154	ND	0.0076	0.0042	ND	ND	0.0004	0.0844
9	5	ND	0.0014	0.0069	ND	ND	ND	0.0060	0.0651	ND	ND	0.0002	0.0864
10	6	ND	0.0064	0.0326	0.1938	ND	0.0003	0.0050	0.1385	ND	0.0006	ND	0.0699
11	7	ND	0.0140	0.0047	0.0011	0.0018	ND	0.0041	0.0054	ND	ND	0.0006	0.0081
12	8	0.0574	0.0173	0.0010	0.3462	0.0035	ND	0.0004	0.0345	ND	ND	0.0013	0.0753
13	9	ND	0.0107	ND	ND	0.0100	ND	0.0033	ND	ND	0.0007	0.0004	0.0867
14	10	ND	0.0011	0.028	0.2136	0.0298	ND	0.0024	0.0092	ND	ND	0.0005	0.0770
15	11	ND	0.0127	0.0210	0.1990	ND	0.0001	0.0049	0.1806	0.1679	0.0023	0.0005	0.0739
16	12	ND	0.0064	0.0130	0.0089	ND	0.0003	0.0040	0.0049	ND	ND	0.0005	0.0843
17	15	ND	0.0124	0.0197	0.1408	0.0263	0.0169	0.0153	0.1200	ND	0.0007	0.0003	0.0842
18	16	0.0376	0.0045	0.0085	0.4402	0.0416	ND	0.0041	0.2757	ND	ND	0.0017	0.0567
19	17	0.0572	0.0054	0.0141	0.2609	0.0339	ND	0.0122	0.1601	ND	0.0001	0.0005	0.0705
20	18	0.0267	0.0093	0.0057	0.1680	0.0578	ND	0.0074	0.0516	ND	0.0006	0.0006	0.0531
21	19	0.0011	ND	0.0069	0.2009	0.0045	ND	0.0005	0.0666	ND	0.0012	0.0006	0.0568
22	20	0.0522	0.0145	0.0045	0.1074	0.0034	0.0015	0.0005	0.0437	ND	ND	0.0005	0.0493
23	21	0.1414	0.0087	0.0253	0.5299	0.1655	ND	0.0081	0.1364	ND	0.0001	0.0008	0.1041
24	22	ND	0.011	0.0125	0.5007	ND	0.0336	0.0091	0.0444	ND	ND	0.0005	0.1212
25	23	ND	0.0092	0.0081	0.3252	0.1502	ND	0.0044	0.0581	ND	0.0002	0.0008	0.1263
26	24	ND	0.0003	0.0225	0.2326	0.3086	0.006	0.0047	0.0460	0.1886	0.0002	0.0007	0.1373
27	25	0.0685	0.0131	0.0057	0.7448	0.3578	ND	0.0030	0.0106	ND	ND	0.0008	0.1049
28	26	0.0230	0.0017	ND	0.3993	0.3606	ND	0.0048	0.0157	ND	0.0007	0.0011	0.0774
29	27	ND	0.0001	ND	0.2065	0.4383	ND	0.0051	0.1082	ND	ND	0.0009	0.0997
30	28	ND	0.0082	0.0153	0.0731	ND	0.0004	0.0042	0.0042	0.1454	ND	0.0003	0.0116
31	29	ND	0.0050	0.0115	0.3142	0.3050	ND	0.0044	0.0187	ND	0.0001	0.0005	0.0745

Cont. table (3): The concentration of some trace elements (ppm) in the surface water and groundwater samples at the study area

Serial No.	Sample No.	Al	Cr	Cu	Fe	Mn	Ni	Pb	Zn	B	Cd	Co	Ba
Groundwater samples													
32	30	ND	0.0100	0.0377	0.3555	0.2469	ND	0.0063	0.0279	ND	0.0003	0.0003	0.744
33	31	ND	0.0066	0.0139	0.1620	0.0786	ND	0.0045	0.0002	ND	ND	0.0006	0.0523
34	32	ND	ND	0.0040	3.286	0.5483	0.0007	0.0026	ND	ND	ND	0.0013	0.0800
35	33	ND	0.0018	0.0066	0.1200	0.1267	ND	0.0042	ND	ND	ND	0.0003	0.0693
36	35	0.1245	0.0014	0.0079	0.2957	0.0743	0.0005	0.0004	0.0161	ND	ND	0.0017	ND
37	37	ND	0.006	0.216	ND	ND	ND	0.0003	ND	ND	ND	0.0010	ND
38	38	ND	0.0065	0.0288	1.376	0.6219	ND	0.0012	ND	ND	ND	0.0007	ND
39	39	ND	0.0066	0.0062	1.046	0.3980	ND	0.0033	ND	ND	ND	0.0005	ND
40	40	ND	0.0055	0.0129	1.258	0.3820	ND	0.0013	0.0013	ND	ND	0.0006	ND
41	41	ND	0.0030	0.0239	0.5386	0.3243	ND	0.0039	0.0017	ND	ND	0.0008	ND
42	42	ND	0.0078	0.0283	1.722	0.7008	ND	0.0049	0.0004	ND	ND	0.0011	ND
43	43	ND	ND	0.040	1.927	0.6573	ND	0.0028	0.0056	ND	ND	0.0009	ND
44	44	0.0465	0.0101	0.132	1.857	0.8213	ND	0.0047	0.0111	ND	ND	0.0009	ND
45	45	ND	0.0106	0.0315	0.2827	0.2118	ND	0.0086	0.0516	ND	ND	0.0004	ND
Permissible		0.2	0.05	1.5	0.3	0.4	0.07	0.01	0.05	1.00	0.003	0.05	0.7

3.2.1.2.2- Nitrite content (NO_2^-): Nitrite (NO2-) content in El-Nasery canal and the oxidation pond water samples ranges from 0.02 – 0.08 and 7.65 – 15.1 mg/l, respectively. The concentration of groundwater samples at the study area ranges from 0.02 mg/l (well No.21) to 4.08 mg/l (well No.12) with an average of 0.88 mg/l. The data in Table (4) indicated that most of the groundwater samples (60%) in the study area have NO2- content more the acceptable limit (0.2mg/l), this is may be due to the agriculture activity and the seepage from the drainage water (oxidation ponds) which show a higher concentration of nitrite.

Table (4): Concentration of nitrogen forms and phosphate compounds (mg/l) in the surface water and groundwater samples at the study area

Serial No.	Sample No.	NH_3	NO_2^-	NO_3^-	Total N	PO_4^{3-}
Surface water samples						
El-Nasery canal						
1	34	4.2	0.02	1.84	6.06	0.11
2	36	3.5	0.08	1.75	5.33	0.14
Drainage water samples (Oxidation ponds)						
3	13	15.4	15.10	16.85	47.35	1.78
4	14	63	7.65	11.20	81.85	2.16
Groundwater samples						
5	1	3.5	0.15	3.03	6.68	0.16
6	2	4.2	2.89	14.50	21.59	0.15
7	3	4.2	0.75	20.88	25.83	0.15
8	4	2.8	0.21	0.49	3.50	0.13
9	5	4.2	0.29	0.58	5.07	0.13
10	6	2.8	0.46	12.84	16.10	0.15
11	7	6.3	3.31	8.25	17.86	0.86
12	8	4.2	4.08	22.84	31.12	0.11
13	9	3.5	0.38	0.41	4.29	0.10
14	10	4.9	0.17	0.24	5.31	0.11
15	11	3.5	3.70	37.80	44.70	0.24
16	12	2.8	2.58	7.88	13.26	0.58
17	15	2.8	0.21	0.57	3.58	0.13
18	16	4.2	0.48	0.29	4.97	0.13
19	17	4.2	0.07	0.78	5.05	0.75
20	18	2.8	0.16	1.29	4.25	0.32
21	19	2.8	0.02	1.94	4.76	0.11
22	20	4.2	0.22	11.07	15.49	0.17
23	21	2.8	1.25	5.23	9.28	0.13
24	22	2.8	0.28	4.26	7.34	0.11

Cont. table (4): Concentration of nitrogen forms and phosphate compounds (mg/l) in the surface water and groundwater samples at the study area

Serial No.	Sample No.	NH_3	NO_2^-	NO_3^-	Total N	PO_4^{3-}
Groundwater samples						
25	23	3.5	0.45	0.21	4.16	0.13
26	24	3.5	2.55	32.22	38.27	0.11
27	25	2.8	1.32	0.14	4.26	0.10
28	26	4.2	0.49	0.14	4.83	0.10
29	27	2.8	1.22	0.09	4.11	0.10
30	28	2.8	0.81	48.50	52.11	0.11
31	29	3.5	1.10	0.03	4.63	0.11
32	30	3.5	0.40	0.12	4.02	0.11
33	31	4.2	0.06	0.03	4.29	0.10
34	32	3.5	0.79	19.70	23.99	0.11
35	33	3.5	0.17	0.09	3.76	0.11
36	35	4.2	0.06	1.41	5.67	1.55
37	37	3.5	0.23	22.92	26.65	0.19
38	38	6.3	0.09	0.05	6.44	0.15
39	39	4.2	0.39	1.85	6.44	0.11
40	40	3.5	0.26	5.46	9.22	0.11
41	41	4.2	0.18	0.60	4.98	0.15
42	42	3.5	0.56	0.21	4.27	8.42
43	43	3.5	0.86	0.68	5.04	0.88
44	44	4.2	1.10	0.05	5.35	0.94
45	45	2.8	1.00	0.12	3.92	0.38
Permissible Limit		0.50	0.2	45	50	1

3.2.1.2.3 - Nitrate content (NO_3^-): Noteworthy to mention that the NO_3^- is considered the final stage of NH_4^+ oxidation passing with NO_2^- in the presence of bacteria and oxygen.

$$\text{Nitrate } (NO_3^-) \xrightarrow[\text{Reduction}]{\text{Microbial}} \text{Nitrite } (NO_2^-)$$

The primary source of nitrates in the groundwater is the leaching of NO_3^- salts into the groundwater supply from fertilizers and the seepage of sewage water. *Liu et al. (2005)* stated that agricultural practices result in non–point source pollution of groundwater and the effect of these practices accumulate confirm over time. Point sources of N such as septic system contribute to nitrate pollution of groundwater.

The concentration of nitrate in El-Nasery canal and the oxidation water samples varies between 1.75 – 1.84 and 11.20 – 16.85 mg/l, respectively. The concentration of nitrate in the groundwater samples at the study area ranges from 0.03mg/l (well No.31) to 48.50mg/l (well No.30) with an average of 3.90mg/l. It is important to mention that El-Nasery canal and the groundwater samples, except one sample (No.30) that have nitrate concentrations less than the permissible limit (45mg/l). This is due to the instability of the nitrate and its reduction to nitrite.

3.2.1.2.4- Total nitrogen content: Total nitrogen calculated by the summation of all nitrogen forms (NH_4^+, NO_2^- and NO_3^-). The total N concentrations for El-Nasery canal and the oxidation ponds samples varies between 5.33 – 6.06 and 1.20 – 16.85mg/l, respectively. The groundwater samples at the study area have total nitrogen ranges from 3.50mg/l (well No.8) to 52.11mg/l (well No.30) with an average of 11.39mg/l.

In general, the presence of high ammonium concentration in some water samples more than the nitrate concentration, confirms that the concerned water subjected to reducing conditions more than oxidizing ones. On the contrary, NO_3^- concentration exceeds NH_4^+ in the rest of the samples confirms the prevalence oxidizing condition.

3.2.1.3-Phosphate content (PO_4^{3-}): Phosphate concentrations in El-Nasery canal and the oxidation ponds water samples was found to be in the range from 0.11– 0.14 and 1.78 – 2.16mg/l, respectively. On the other hand, the concentration of Phosphate in the groundwater samples at the study area as shown in ranges from 0.10mg/l (well No.13) – 8.42mg/l (wellNo.42) with an average of 0.12mg/l. In conclusion all the water samples in the study area lie within the acceptable limit according to WHO (1996) because all of them have concentrations less than 1mg/l, with exception of two groundwater samples (35 and 42). The lowest concentration of phosphate is due to soil capability of adsorption for phosphate ions.

3.2.2-Biological pollutants: The biological pollutants in the surface water and groundwater samples at the study area was discussed through the determination of total organic carbon (TOC), biological oxygen demand (BOD) and chemical oxygen demand (COD) as in table (5).

3.2.2.1- Total Organic Carbon (TOC): The obtained values of the TOC were in the range from 8.2 – 8.6mg/l and 111 to 146mg/l for El-Nasery canal and the oxidation ponds water samples, respectively. On the other hand, the groundwater samples have TOC concentration ranges from 4.1 to 8.2mg/l with an average of 5.8mg/l. The results of TOC reveal that both of El-Nasery canal water samples and 44% of the selected groundwater samples at the study area are fairly polluted as they have concentrations to some extent close to the contamination limit (10mg/l), this is due to the seepage from the oxidation ponds that have higher values than the permissible limit, which reveal the pollution of it.

3.2.2.2 - Biological Oxygen Demands (BOD): El-Nasery canal water sample have not biological oxygen demands contents. The oxidation water samples are polluted as they have BOD values ranging from 111 – 137mg/l, while the selected groundwater samples in the study area have BOD values range from 0 to 6.4mg/l, with a mean value of 1.37mg/l. These data mean that the oxidation ponds act as a reduction agent for the pollution of human activity. The majority of the selected groundwater samples in the study area have BOD values less than the contamination limit except one sample, which indicates the human activity at El–Sadat city and the effect of the oxidation ponds. The appearance of some contaminated groundwater samples confirms the occurrence of pathogenic microorganisms belong to the family interbacteriaceae in such water samples.

Table (5): The biological measurements for some selected water samples in the study area expressed as mg/l

Serial No.	Sample No.	TOC	BOD	COD
Surface water samples				
El-Nasery canal				
1	34	8.2	0	32.1
2	36	8.6	0	33.4
Drainage water samples (Oxidation ponds)				
3	13	111	137	102.3
4.	14	146	111	88.8
Some selected groundwater samples				
5	1 (Well 1)	4.1	0	15.3
6	2 (Well 2)	4.8	2.9	19.3
7	3 (Well 3)	5.6	3.4	31.3
8	4 (Well 4)	8.2	0	16.2
9	5 (Well 5)	4.7	0	36.4
10	8 (Well 8)	6.3	2.6	41.3
11	11 (Well 11)	7.2	0	40.1
12	12 (Well 12)	6.1	0	18.1
13	16 (Well 14)	8.0	2.3	15.1
14	23 (Well 21)	4.4	1.9	13.8
15	24 (Well 22)	4.9	0	15.9
16	25 (Well 23)	5.3	0	18.4
17	29 (Well 27)	5.7	2.4	19.3
18	34 (Well 32)	6.2	6.4	21.6
19	40 (Well 40)	5.3	0	19.3
20	42 (Well 42)	6.2	0	22.4
Permissible Limit		10	6	10

3.2.2.3 - Chemical Oxygen Demands: The obtained results of COD obviously do not correspond to the values of BOD, where COD values are higher than the BOD values. This is useful where it may helpful in comparing conditions in stream at one time to another time. The COD values range 32.1 to 33.4mg/l and 88.8 – 102.3mg/l for El-Nasery canal and oxidation ponds water samples, respectively. The selected groundwater samples at the study area have COD contents range from 13.8 to 41.3mg/l with a mean value of 22.74mg/l, it noticed that the values of COD contents in all surface and groundwater water samples (El Nasery canal and groundwater samples) are higher than the permissible limit due to the direct effect of seepage of drainage water (Oxidation ponds) to the groundwater samples.

3.2.3- Microbial pollutants: This part of pollution will be discussed based on the microbial analysis of selected water samples at the study area (20 water samples;2 surface water samples from El–Nasery canal, 2 water samples from the oxidation ponds and 16 groundwater samples) as shown in table (6).

The obtained data indicate that the total viable counts (TVC_S) vary between 19 x 10^2 to 21 x 10^2 cfu/ ml for El-Nasery canal, 220 x 10^2 to 360 x10^2 cfu/ ml for the oxidation ponds and 10.2 x 10^2 to 45.0 x 10^2 cfu/ ml for groundwater samples. The total Coliforms (MPN) range from 1100 – 1300 cfu/ 100 ml for the oxidation ponds and 0-20 cfu/100 ml groundwater samples, while being nil for El-Nasery canal. The faecal coliforms of the study water samples range from 32 – 38 cfu/ 100 ml for the oxidation ponds and 0-5 cfu/100 ml for groundwater samples, while being nil for El-Nasery canal. It is important to mention that the recommended of the total coliforms standard value for wastewater is (1 x 10^2 cfu/ml), while being nil for natural water, FAO (1997) and Okonko et al., (2008). These data agreed with El Sayed et al., (2012) who observed high total colony counts of the wastewater of the studied areas. There were four groundwater samples have total and faecal bacteria (E. coli) , which are unsutable for drinking human, livestock and poultry. However, the water from the oxidation ponds have both of E.

coliand and Salmonella typhi, indicating the unsuitability of using this type of water for drinking or irrigation the economic crops either eaten uncooked or cooked, while it may be used to irrigate the wood trees as happened at El–Sadat city.

According to WHO (2011), the recommended limits for irrigation vegetables likely to be eaten uncooked was 200 MPN/100 ml and irrigation the ornamental fruit trees and fodder crops was 1000 MPN/ 100 ml.

Therefore, all groundwater samples (except the mentioned four samples) and the surface water samples from El–Nasery canal are suitable for drinking, industrial and agricultural purposes. However, the four groundwater samples were not suitable for irrigation the vegetables especially which eaten uncooked.

Finally; it can be concluded that this study proved that the quality of groundwater in the study area affected by the seepage from oxidation ponds. This is confirmed by the previous study as Khurana and Pritpal (2012) that revealed that the chemical composition of groundwater varies remarkably with their heavy metal content, pH, EC, biochemical oxygen demand (BOD), chemical oxygen demand (COD) and alkalinity and hardness.

Table (6): The total viable bacteria counts (TVBC) x 102 cfu/ml, the most probable number (MPN) of total coliforms (TC), fecal coliforms (FC)/ 100ml and triple sugar iron for the selected water samples at the study area

Serial No.	Sample No.	Total Coliforms MPN/100 ml	Fecal Coliforms cfu /100 ml	Total microbes counts (TVC) x 10^2 cfu / ml	TSI Triple Sugar Iron
Surface water samples					
El-Nasery canal samples					
1	34	19.0	-	-	-
2	36	21.0	-	-	-
Drainage water samples (Oxidation ponds)					
3	13	220	1100	38	*E. Coli* + *Salmonella typhi*
4	14	360	1300	32	*E. Coli* + *Salmonella typhi*
Groundwater samples					
5	1 (Well 1)	10.2	-	-	-
6	2 (Well 2)	12.1	-	-	-
7	3 (Well 3)	19.4	-	-	-
8	4 (Well 4)	26.5	-	-	-
9	5 (Well 5)	12.1	-	-	-
10	8 (Well 8)	20.2	-	-	-
11	11 (Well 11)	38.0	20	5	*E. Coli*
12	12 (Well 12)	45.0	20	4	*E. Coli*
13	16 (Well 14)	12.4	-	-	-
14	23 (Well 21)	19.5	-	-	-
15	24 (Well 22)	11.6	-	-	-
16	25 (Well 23)	0.3١	-	-	-
17	29 (Well 27)	29.0	15	3	*E. Coli*
18	34 (Well 32)	25.3	15	5	*E. Coli*
19	40 (Well 40)	18.4	-	-	-
20	42 (Well 42)	13.2	-	-	-
Permissible Limit		100/ml	20/100 ml	0	

3.3- Water Evaluation: Water quality evaluation for different purposes such as human drinking, laundry, agricultural and industrial was evaluated according to international standards, Egyptian higher committee for water (2007) and WHO (2011).

3.3.1 - Evaluation of the water quality for human drinking: Comparing the obtained data (table 1) and the international standards as mentioned in the table (7), can be concluded that;

According to the salinity, the surface water samples in the study area (El–Nasery canal) is suitable for drinking as they have salinity vary from 296 to 303mg/l, i.e., less than the permissible limit (1200mg/l). On the other hand, the majority of the groundwater samples (90%) in the study area are suitable for human drinking, as they have salinity less than 1200mg/l, while the rest of the groundwater samples (10%) in the study area are unsuitable for human drinking as they have salinity more than 1200mg/l.

By comparing the maximum permissible limits of heavy and trace constituents (Fe, Pb, Cr, Cu, Co, Cd and Zn) as shown in table (7) for drinking water with the obtained data (table 3), it is found that El-Nasery canal water are unsuitable for drinking as they have Fe concentrations more than the permissible limit at these locations. On the other hand, 61% of the groundwater samples in the study area are suitable for drinking as they have concentrations of heavy and trace constituents less than the permissible limit of contamination, while the rest of the samples (39%) are unsuitable for drinking as they have Cr, Fe, Mn and Zn concentrations higher than the permissible limits.

Table (7): Water quality guidelines for human drinking and domestic uses. (According to the international standards)

Chemical constituent or parameter	**Eurppean[1] Standar`ds mg/l**	**International[2] Standards mg/l**	**Egyptian[3] maximum limits in mg/l**	**World[4] Health Organization guidelines mg/l**
Aluminum	0.05 to 0.2	-	0.2	0.2
Arsenic	< 0.05	< 0.05	0.0	-
Barium	< 1.00	<1.0	1.0	-
Boron*	1.00	-	-	-
Cadmium	< 0.01	< 0.01	0.005	-
Calcium	75 - 200	75 - 200	200	-
Chloride	-	-	500	250
Copper	< 0.05	0.05 – 1.5	1.00	1.00
Cyanides	> 0.05	< 0.05	0.05	-
Fluoride	-	1.4 – 2.4	0.8	-
Hardness as $CaCO_3$	2 – 10me/l	2 – 100 me/l	500 mg/l	-
Iron (total)	< 0.1	0.1 – 1.0	0.3 – 1.0	0.3
Magnesium If SO_4> 250 mg/l If SO_4<250 mg/l	< 30 < 125	< 30 < 125	150	-
Manganese	< 0.01	0.1 – 0.5	0.001	0.1
Mercury (total)	< 0.01	< 0.01	0.001	-
Nitrate as N recommendation Acceptable Not recommended	<50 for bodies less than three months 50 – 100 for Older children and adults > 100	-	10	-
TDS	-	500 - 1500	1200	1000
pH	7 – 8.5	-	6.5 – 9.2	-
Sodium	-	-	200	200
Sulfates	< 250	250 - 400	400	250
Zinc	< 5	5 - 15	5	3
Lead	< 0.1	< 0.1	0.05	-

1- World Health Organization (1971). European standards for drinking water, secon edition, Geneva, WHO.

2- World Health Organization (1972). International standards for drinking water, 3rd edition, Geneva, WHO.

3- Egyptian standards for drinking and domestic uses (Higher Committee for water, 2007).

4- World Health Organization (2011). Guidelines of drinking water quality. Incorporating First Addendum 4th edition, Geneva, WHO.

CONCOLUSION

1 – The chemical fertilizers and pesticides should be used at minimum limits as they considered a part of water pollution at El–Sadat city.

2 – Industrial wastewater should be treated at the industry's site before being delivered in the oxidation ponds, where it may be recycled at the plant.

3 – The groundwater in the study area must be treated before using.

4- Carrying out periodical chemical, biological and microbial analysis for the water resources in the study area to follow up the changes of these sources especially in groundwater nearer to the oxidation ponds.

REFERENCE

American Public Health Association, (APHA), (1989): Standards Methods for the Examination of Water and Wastewater. 17thedition, New York, U.S.A.

Chebotarev, I.I., (1955): Metamorphism of natural waters in the crust of weathering. Geochemia et.Cosmochimica, Acta, 8, part I. pp.22-48, part II. pp.137-170 and part III. pp.198-212, Londonand New York.

El- Sayed, M.M; El Aassar, A.M.; Abo El – Fadi, M.M and Abd El – Gawad, A.M. (2012): Hydro- geochemistry and pollution problems in 10th of Ramadan city, east El – Delta, Egypt. J. Appl. Sci. Res., 8, 4, 1959 – 1972.

El – Tahawy, M.; Nassef, M.; Gamal, Y.andZaki, L. (2006): Radiological of natural and man -made radioactivity in two new industrial Egyptian cities. VIII Radiation Physics & Protection Conference, Assessment of industrial contamination of agricultural soil adjacent to El- Sadat city, Egypt.

Egyptian Higher Committee for water (1997): Egyptian standads for drinking water and domestic uses. Egypt (in Arabic).

Fishman, A.E and Friedman, L.G., (1985): Methods for determination of inorganic substance in water and fluvial sediments. U.S. Geo,Sur., Book 5, Chapter A1. Open File Report, pp. 485 – 495, Denver, Colorado, U.S.A.

Food and Agriculture Organization , FAO (1997): Chemical analysis manual for food and water. 5th Ed., Roma, Italy, 1, 20 – 26.

Higher Committee for water (2007): Egyptian standards for drinking water and domestic uses. Cairo, Egypt (In Arabic).

Khurana, M.P.S.andPritpal, S. (2012): Wastewater use in crop production: A Review. Resources and Environment, 2, 4, 116 -131.

Okonko, I.O.; Adejoye, O.D.; Ogunnusi, T.A.; Fajobi, E.A. and Shittu, O.B., (2008): Microbiological and physicochemical analysis of different water samples used for domestic purposes in Abeokuta and Ojota. Lagos State, Nigeria. Afr. J. Biotechnol., 7 (3): 617-621.

Rainwater, F.H. and L.L. Thatcher, (1960):. Methods for collection and analysis of water samples. U.S.

Wael Badway; ClesyaYa. Chepurchenko; Hussein El- Salman and Mariana V. Frontasyeva (2016): Assessment of industrial contamination of agricultural soil adjacent to Sadat city, Egypt. Chem. Eng., 23, 2, 297-310.

World Health Organization (1996): Guidelines for drinking water quality. Geneva, 2nd edition, Vol. 2, Health Criteria and other supporting information.

World Health Organization, (2011): Guideline of drinking water quality, Incorporating First Addendum. 4th ed., Geneva: World Health Organization.

تأثير العوامل البيئية المختلفة على خواص المياه الجوفية بمنطقة السادات – مصر

[١]

نورا عبد الرحمن محمد عبد الرحمن[١]– طه عبد العظيم محمد عبد الرازق[١]
يحيى رجب جدامى[٢]

١) معهد الدراسات والبحوث البيئية، جامعة عين شمس، القاهرة، مصر ٢) مركز بحوث الصحراء، القاهرة، مصر

المستخلص

تهدف هذه الدراسة إلى تقييم الوضع الهيدروكيميائى ومدى التلوث الكيميائي والميكروبى للمياه بمنطقة السادات. تم ذلك من خلال جمع ٤٥ عينة مياه تمثل (عدد ٤ عينات مياه سطحية منها عينتان من مياه الرياح الناصرى وعينتان من بركتى الأكسدة المجمعة لمياه الصرف المختلفة بالمدينة وعدد ٤١ عينة مياه جوفية ممثلة لوضع المياه الجوفية بالمنطقة). تم تقدير بعض الخواص الكيميائية في عينات المياه المأخوذة مثل الأس الهيدروجيني (pH) ودرجة الملوحة (EC) والأملاح الكلية الذائبة (TDS) وكذلك تم تقدير بعض العناصر النادرة والمعادن الثقيلة علاوة على تقدير الكاتيونات والأنيونات والسليكا والفوسفات فى تلك العينات، وكذلك تقدير بعض الملوثات الكيميائية مثل الكربون العضوى الكلى (TOC ,BOD, COD) وبعض العناصر النادرة والثقيلة وبعض الميكروبات الممرضة مثل E. coli، Salmonella typhi.

أظهرت النتائج أن نوعية المياه المتواجدة في منطقة الدراسة تتمثل في نوعين من المياه هما المياه العذبة (93% من مجموع العينات المأخوذة) والمياه الضاربة للملوحة (٧%) من مجموع العينات المأخوذة علاوة على أن الأس الهيدروجيني لجميع العينات المدروسة أكبر من ٧,٠ ماعدا عينتان. أيضا أظهرت النتائج خلو مياه الرياح الناصرى ومعظم المياه الجوفية من معظم العناصر الثقيلة الملوثة للبيئة وكذلك خلوها من الميكروبات الممرضة، ماعدا ٤ عينات من عينات المياه الجوفية والتي ظهر فيها الميكروبات المرضية E. Coli وبذلك يجب الحذر عند استخدام تلك النوعية

من المياه في رى المحاصيل خاصة محاصيل الخضر والتي تؤكل طازجة (غير مطبوخة). أما عينات مياه برك الأكسدة فإنها تحتوى على تركيزات عالية من معظم العناصر الثقيلة علاوة على احتوائها على نوعين من الميكروبات الممرضة هما E. coli وSalmonella typhi مما يؤكد عدم استخدامها إلا فىرى الأشجار الخشبية كما يحدث حاليا فى مدينة السادات. ومن تلك النتائج المتحصل عليها نجد أن معظم المياه السطحية من الرياح الناصري والمياه الجوفية خالية من الملوثات المعدنية والعضوية والميكروبية وبالتالىفهى صالحة لجميع الاستخدامات التى يحتاجها الأنسان فى حياته اليومية. ويجب التوصية بمعالجة المياه قبل استخدامها وإجراء التحاليل الكيميائية والبكترولوجية خلال الفترات المتتابعة.

الكلمات الدالة: مياه جوفية، مدينة السادات، تلوث كيميائي، تلوث ميكروبي.