Hydrochemical Classification of Groundwater in West Assiut Combined Cycle Power's Area, Assiut, Egypt

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Abstract

Groundwater is the main source for water used in West Assiut Electric Power Plant (WACCPP), so here we will study the hydrochemical class and water type for WACCPP area's groundwater, with respect to the physiochemical, chemical elements and chemically related properties. Hydrochemical formulae's as Kurolov formula, hypothetical salts, hydrochemical indices and water type identification programs as Piper, Durov, Schoeller, Gibb, and Chadha will be applied for deciding the water class and type.

Keywords: Groundwater, WACCPP, hydrochemical parameters, Hypothetical salts, Hydrochemical indicators, Hydrochemical faces.

Introduction

Water is being used for electric power generation and different purposes nowadays from traditional sources as Nile River and, non-traditional water sources such as seawater, excessively hard or brackish groundwater, poorer quality surface waters, and wastewater [1]. These sources commonly require treatment with high quality technologies before use. In West Assiut Combined Cycle Power Plant (WACCPP) groundwater is used as the main source for demineralized water production, for this purpose, 37 wells were drilled there. In this paper, we will examine the type and hydrochemical class of the area's groundwater. The groundwater is considered the source of water for domestic, agricultural and industrial uses in many Arab countries [2]. This demand has faced by the groundwater quality that affected by the following processes: Chemical reactions with geological materials, geochemical reactions, biodegradation, Dissolution [2] and exsolution of gases [3] and anthropogenic pollution[4]. The water quality is in equal importance to its quantity, so it is necessary to analyze groundwater chemical, physiochemical and hydrochemical properties, any deviation from the standard value for one or more of a water quality's parameters, water is considered polluted. Also, determining water type and quality depend on the hydrochemical parameters for the groundwater as hydrochemical formula (Kurolov formula) and water type, hypothetical Salts, hydrochemical indicators and index of base exchange.

On the other hand, methods are used for hydrochemical classification of groundwater are Piper, Piper and Langguth, Durov, Schoeller, Gibband Chadha, those are constructed depending on the main cations and anions concentrations by unit equivalent weight of ion in mills equivalent per liter(epm) and epm %.

Experimental

2.1. Materials and Methods

2.1.1. Study Area

Assiut is the largest town in Upper Egypt and lies about 234 miles south of Cairo. The city of Assiut is located at 27°11`00̀ N, 31°10`00̀ E and spread across 26,000 km2.WACCPP is located at the northern west of Assiut city in Assiut governorate in Upper Egypt, and allocated from Assiut city by 25 km and at about 5 km from Bany Ghalleb and about 3.43 km from the nearest village Jhdum, Located between the Petroleum Company in the north and cement company in the south, it is on a 33.6 acres area. The wells were lied in the south, east, and west sides of the area, the water depth is about 80m and the overall wells deep is 200m. In WACCPP, power plants use the demineralized water for : Steam generation, cooling, sealing, de-NOx, washing and so on. West Assiut power plant specifications, Table (1).

Table (1): Description of WACCPP's Constituents

Item	Description
Simple cycle	Two Modules of gas turbines, contains 8 gas turbine units, power capacity.
Power capacity	125 MW/hr for each gas turbine
Exhaust gases temp.	590ºC
Water uses	176 ton/hr injection waters for d-NOx, Makeup water for closed cooling system, Washing water for the turbine and compressor offline washing
Description the constituents of combined cycle stage's	
Combined cycle	Two Modules of HRSGs, one on each module of simple cycle
Power capacity	250 MW/hr for each module
Exhaust gases temp.	150 ºC
Water uses	Makeup water for closed thermal cycle, Makeup water for closed cooling system, Washing water for the HRSGS offline washing
Steam ton/hr	840 ton/hr for each combined
Steam pressure bar	116

2.1.2. Sampling and analytical procedures (Measure of Parameters)

Water samples from the thirty seven wells and raw water(mixture tank) in WACCPP (study area) were withdrawn and sample's bottles were prepared according the ASTM standards and the water samples were taken under almost careful conditions after the water was pumped out for about 10 minutes to remove the stagnant water. All samples were preserved in refrigerator before chemical analysis. The samples were analyzed for determining its content of : pH, EC, TDS. Also trace elements were analyzed as important cations like Calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}) and anions like bicarbonate (HCO^{-3}), Chloride (Cl^{-}), Nitrate (NO^{-3}), Carbonate (CO^{-3}) and Sulfate (SO_4^{-2}). the measurements were conducted according to the standard specification using; HANA (HI9811-5) instrument volumetric method[5], flame photometer[6], titration[7], ultraviolet spectra (U.V), atomic absorption [8].All concentrations were expressed in milligrams per liter (mg/L), except for pH and EC. Ionic-balance-error was checked for accuracy of each groundwater sample, which is generally within acceptable limit of ±5 %.

2.1.3. Determination of groundwater type was done using :

1- Hydrochemical formula (kurolov formula)

It depends on the ratio of cation and anions, which have ratio of availability more than 15% as in Eq.(1) [9]:

$$TDS\ mg/L = \frac{Anions\ epm\%\ decreasing\ order}{cations\ epm\%\ decreasing\ order}\ pH \qquad (1)$$

2- Hypothetical salts

Hypothetically, the ions of strong acids Cl^- and SO_4^{2-}, form a chemical combination with alkalis, Na^+ and K^+ and the rest of acid radicals combine with alkaline earths Ca^{2+} and Mg^{2+}[10]. If the cations of alkali and alkaline earths all in epm % are surplus in groundwater [11], they will combine with anions of the weak acids CO_3^{2-} and HCO_3^-[10,12].

3- Hydrochemical Indicators

They were used to determine the origin of the groundwater; meteoric or marine water and helped in discovering the previous hydrochemical processes affecting water quality [9]. These indicators are a ratio between the different major ions. Cl^- ion is considered a well defining mean in determining the origin of water, (where the ratio of main elements to Cl^- gives geochemical behavior for the main elements) [13].

4- Index of Base Exchange

The exchange between alkali metals cations and alkaline earth metals cations in the water and its host environment during residence or travel periods could be determined by the chloro-alkaline indices (CAI) [14, 15]

2.1.4. Hydrochemical classification of groundwater

Using Aquachem v3.7 software for better understanding of hydrochemistry, water quality and its evaluation by comparing the water types and to interpret variation in hydrochemical processes. Piper [16], Durov [17], Schoeller [18], Gibb [19] and Chadha [20] diagrams were constructed depending on the main cations and anions concentrations by unit equivalent weight of ion in mille equivalent per liter (epm) and epm % [20].

2.1.5. Hydrochemical Faces

The hydrochemical faces has been studied based on Chebotarev sequence[4, 21]. In Chebotarev sequence, he proposed a geochemical classification of water based on anion occurrence and prevalence as they are regarded as independent ingredients, the chemical quality of groundwater is classified into three major groups according to major anions and TDS, respectively [21].

3. Results and Discussion

3.1. Physical Specifications Results

Wells and Raw water sample's physical analysis results as odor, color, taste, pH, TDS and EC were analyzed and determined as in **Table (2)**

Table (2): Analysis of physical parameters of water samples

Item	1A	1B	2A	2B	3A	3B	4A	4B	5A	5B	6A	6B	7A	7B	8A	8B	9A	9B	10A	10B
EC	2540	4980	2700	3300	1924	5130	1034	1446	2060	2260	1736	2580	1323	1393	3120	1557	2650	1469	1730	2980
pH	8.3	7.75	8.39	7.71	8.3	7.55	8.4	8.34	8.37	7.59	8.4	7.61	7.85	8.02	7.34	7.88	7.67	7.75	8.39	7.82
TDS	1625	3187	1720	2112	1231	3283	663	925	1319	1438	1114	1651	846	891	1997	996	1696	940	1104	1910

Table (2); continued

Item	11A	11B	12A	12B	13A	13B	14A	14B	15A	15B	16A	17A	18A	19A	19B	20A	20B	Raw
EC	2120	2610	1690	2940	4000	4165	5061	4080	1473	1847	2190	1283	1156	1170	1914	1004	1509	4680
pH	7.89	7.05	7.81	7.74	7.65	7.9	7.7	7.8	8.1	7.87	7.45	7.94	8.38	8.46	7.89	8.33	7.6	7.38
TDS	1356	1669	1081	1881	2400	2707	3280	2652	943	1182	1404	821	740	749	1224	643	966	2858

From Table (2), it can be noted that PH values vary between 7.05 and 8.46, reflect neutral to slightly alkaline water, electric conductivity varies between 1004 and 5130 µs/cm, so wells and raw water are excessively mineralized water, TDS content ranging from 643 to 3283 ppm, so wells and Raw water are fresh to slightly brackish water.

3.2. Chemical Specifications Results

Water samples were analyzed for major cations, major anions, and heavy elements, as shown in Table (3).

Table (3); Analysis of chemical parameters of water samples

Item	1A	1B	2A	2B	3A	3B	4A	4B	5A	5B	6A	6B	7A	7B	8A	8B	9A	9B	10A
Cl	580	1320	748	825	540	1420	192	305	508	505	457	573	279	260	682	325	587	288	399
CO_3	16	0	0	0	26	0	28	10	13	0	26	0	0	0	0	0	0	0	12
HCO_3	268	180	150	278	217	241	250	225	252	225	322	214	325	285	229	225	175	310	320
NO_3	5.9	7.4	0.2	8.8	11.2	0.2	0	3.7	5.7	5.6	8.2	13.5	0.7	0.2	65.5	12.3	33.6	6.2	10
SO_4	185.6	285	160	80	38.6	163	20.3	25	116	82	60.6	165	11.8	22	300	32	130	28.3	60.3
Ca	75.7	183	71.5	74.7	47.2	171	17	20	65.2	60	33.5	77	14.4	24.6	154	25.7	66	31	53.3
K	21.5	5	3	5	4	8	3	4	3.08	6	5.5	11	3	4	3	3	5	7	2.44
Mg	25.7	15	24.2	15	22.6	56.9	13.2	8	15.9	15	9.81	22	9.72	14.2	43.7	8	21	10	13.8
Na	424	885	500	620	370	800	200	280	380	385	282	435	270	250	450	292	534	285	327

Table (3); continued

Item	10B	11A	11B	12A	12B	13A	13B	14A	14B	15A	15B	16A	17A	18A	19A	19B	20A	20B	Raw
Cl	774	510	661	380	752	1134	1250	1449	1153	320	340	534	250	253	231	425	154	338	1160
CO_3	0	0	0	0	0	4	4	4	4	0	0	0	0	24	25	0	13	0	20.4
HCO_3	259	250	195	240	243	111	145	85	150	200	326	235	290	200	207	275	260	231	505
NO_3	6.2	13.5	4.7	7.1	3.9	60	53.6	60	31.2	20.2	0.2	15.3	0.29	0	0.92	0.2	0.2	0.6	11.4
SO_4	110	100	110	93.7	104	235	185	327	187	59.8	44	138	34	31.9	32.8	62.3	57	41	250
Ca	80.7	76.4	64.2	62.2	48.2	160	153	183	136	29.7	52.1	110	20.4	29.3	27.6	35	26	33	200
K	5	5	7	2.65	6	4.6	5.9	5	5.7	4	4	4	2	2	1.17	3	1.26	3	40
Mg	15	16.2	17	26.9	33.8	61	61	73	49	3.49	12.2	40	10.2	16.3	16.8	14	14.7	9	50
Na	575	350	485	254	500	611	610	721	616	280	280	310	240	204	200	370	175	290	595

3.2.1. Data Processing

The results in ppm, epm (meq/l) and in epm% is as shown in Table (4). Also, it was subjected to correctness and instrumentation validity and hydrochemical classification.

Table 4); (major ions+ CO_3 and NO_3) as epm and epm%

Item	1A	1B	2A	2B	3A	3B	4A	4B	5A	5B	6A	6B	7A	7B	8A	8B	9A	9B	10A
CO3 epm	0.53	0	0	0	0.87	0	0.93	0.33	0.43	0	0.87	0	0	0	0	0	0	0	0.4
CO3 epm%	2.11	0	0	0	4.3	0	8.6	2.51	2.01	0	4.3	0	0	0	0	0	0	0	2.2
Clepm	16.3	37.2	21	23.2	15.2	40	5.4	8.6	14.3	14.2	12.9	16.1	7.86	7.32	19.2	9.15	16.5	8.1	11.2
Clepm%	64.7	80.5	78.4	78.5	73.7	84.5	49.8	65.2	66.9	72.1	63.1	69. 2	58.4	58.8	63.5	59	72.9	58.4	61.3
HCO3 epm	4.39	2.95	2.46	4.56	3.56	3.95	4.1	3.69	4.13	3.69	5.28	3.51	5.33	4.67	3.75	3.69	2.87	5.08	5.25
HCO3 pm%	17.4	6.4	9.2	15.4	17.2	8.34	37.8	27.9	19.3	18.7	25.8	15.1	39.6	37.5	12.4	23.8	12.7	36.6	28.7
NO3 epm	0.09	0.12	0.002	0.14	0.18	0.003	0	0.06	0.09	0.09	0.13	0.217	0.011	0.003	1.056	2	0.54	0.1	0.16
NO3 em%	0.36	0.25	0.01	0.47	0.87	0.01	0	0.45	0.42	0.46	0.64	0.93	0.08	0.02	3.49	12.9	2.4	0.72	0.87
SO4 epm	3.87	5.94	3.33	1.67	0.8	3.4	0.42	0.52	2.42	1.71	1.26	3.44	0.25	0.46	6.25	0.67	2.71	0.59	1.26
SO4 epm%	15.4	12.8	12.4	5.6	3.88	7.18	3.87	3.94	11.3	8.68	6.16	14.8	1.86	3.69	20.6	4.32	12	4.25	6.89
Sum epm	25.2	46.2	26.8	29.6	20.6	47.4	10.8	13.2	21.4	19.7	20.4	23.3	13.5	12.5	30.3	15.5	22.6	18.2	13.8
Caepm	3.8	9.15	3.6	3.73	2.36	8.55	0.85	1	3.26	3	1.7	3.85	0.72	1.23	7.7	1.3	3.3	1.55	2.7
Caepm%	15.3	18.7	13.1	11.6	11.5	17.7	7.93	7.16	15.4	14.2	11.4	15.5	5.41	9.18	24.8	8.82	11.6	10.4	14.9
Kepm	0.55	0.13	0.08	0.13	0.1	0.2	0.08	0.1	0.08	0.15	0.14	0.28	0.08	0.1	0.08	0.08	0.13	0.18	0.06
Kepm%	2.21	0.27	0.29	0.41	0.49	0.41	0.75	0.71	0.38	0.71	0.93	1.13	0.6	0.75	0.26	0.543	0.46	1.2	0.33
Mgepm	2.1	1.2	1.99	1.23	1.86	4.68	1.08	0.66	1.31	1.23	0.81	1.81	0.8	1.17	3.6	0.66	1.72	0.82	1.13
Mgepm%	8.45	2.45	7.27	3.83	9.11	9.7	10.1	4.73	6.2	5.83	5.42	7.29	6.01	8.73	11.62	4.48	6.07	5.48	6.24
Naepm	18.4	38.5	21.7	27	16.1	34.8	8.7	12.2	16.5	16.7	12.3	18.9	11.7	10.9	19.6	12.7	23.2	12.4	14.2
Na epm%	74	78.6	79.3	84.1	78.8	72.1	81.2	87.4	78	79.2	82.3	76.1	87.97	81.34	63.27	86.16	81.8	82.9	78.5
Sum epm	24.85	48.98	27.37	32.09	20.42	48.23		13.96	21.15	21.08	14.95	24.84	13.3	13.4	30.98	14.74	28.35	18.09	14.95

Table (4) continued.

	10B	11A	11B	12A	12B	13A	13B	14A	14B	15A	15B	16A	17A	18A	19A	19B	20A	20B	Raw
CO_3epm	0	0	0	0	0	0.13	0.13	0.01	0.13	0	0	0	0	0.8	0.83	0	0.43	0	0.68
CO3epm%	0	0	0	0	0	0.3	0.3	0.02	0.33	0	0	0	0	6.74	7.27	0	4.2	0	1.45
Cl epm	21.8	14.4	18.6	10.7	21.2	31.9	35.2	40.8	32.5	9.01	9.6	15	7	7.13	6.5	12	4.33	9.5	32.7
Cl epm%	76.7	69.3	77	64.1	77.3	80.3	83	81.6	82.3	65	60.5	68.2	56.2	60.1	56.9	67.4	42.4	67.1	69.5
HCO3 epm	4.25	4.1	3.2	3.93	3.98	1.82	2.38	1.39	2.46	3.28	5.34	3.85	4.75	3.28	3.4	4.51	4.26	3.79	8.27
HCO3 epm%	15	19.7	13.2	23.5	14.5	4.58	5.61	2.78	6.23	23.6	33.6	17.5	38.1	27.6	29.79	25.3	41.7	26.8	17.6
NO3 epm	0.098	0.21	0.07	0.11	0.06	0.96	0.86	0.96	0.5	0.33	0.003	0.25	0.004	0	0.014	0.002	0.003	0.009	0.16
NO3 epm	0.34	1.01	0.29	0.66	0.22	2.42	2.03	1.92	1.27	2.34	0.02	1.14	0.032	0	0.123	0.01	0.03	0.064	0.34
SO4 epm	2.29	2.08	2.29	1.95	2.17	4.9	3.85	6.81	3.9	1.25	0.92	2.88	0.71	0.66	0.68	1.3	1.19	0.85	5.2
SO4 epm%	8.05	10	9.48	11.7	7.9	12.3	9.07	13.6	9.9	9	5.8	13.1	5.69	5.56	5.95	7.3	11.6	6	11
Sum epm	28.43	20.79	24.16	16.69	27.41	39.71	42.42	49.97	39.49	13.86	15.86	21.98	12.46	11.87	11.42	17.81	10.21	14.14	47.01
Caepm	4.03	3.82	3.21	3.11	2.41	8	7.65	9.15	6.8	1.5	2.6	5.5	1.02	1.46	1.38	1.75	1.3	1.65	11.9
Ca epm%	13.2	18.6	12.4	18.9	8.91	20.2	19.4	19.6	18	10.6	16.3	24.5	8.28	12.4	12	9.17	12.8	10.9	27.7
K epm	0.13	0.13	0.18	0.07	0.15	0.12	0.15	0.13	0.15	0.1	0.1	0.1	0.05	0.05	0.03	0.08	0.03	0.08	1.02
K epm%	0.428	0.635	0.69	0.427	0.55	0.303	0.38	0.279	0.397	0.71	0.629	0.446	0.406	0.427	0.261	0.42	0.296	0.53	2.37
Mg epm	1.23	1.33	1.4	2.21	2.78	5.02	5.02	6	4.03	0.29	1	3.29	0.84	1.34	1.38	1.15	1.21	0.74	4.11
Mg epm%	4.05	6.49	5.4	13.5	10.3	12.7	12.7	12.9	10.7	2.06	6.29	14.7	6.82	11.4	12.01	6.03	11.9	4.91	9.57
Na epm	25	15.2	21.1	11	21.7	26.5	26.5	31.3	26.8	12.2	12.2	13.5	10.4	8.87	8.7	16.1	7.6	12.6	25.9
Na epm%	82.2	74.2	81.5	67.1	80.2	66.8	67.4	67.2	70.9	86.6	76.73	60.3	84.5	75.7	75.7	84.4	74.9	83.6	60.3
Sum epm	30.39	20.48	25.89	16.39	27.04	39.64	39.32	46.58	37.78	14.09	15.9	22.39	12.31	11.72	11.49	19.08	10.14	15.07	42.93

3.3. Analyses' Correctness and Instrumentation Validity

A few samples with ionic concentrations above 50 epm have been excluded from the analysis, the procedures for checking analyses' correctness and instruments' accuracy as ionic balance and TDS-to-EC ratio were applied to water samples analyses' results.

1- Ionic balance error %:

The anion and cation sums must balance because water is electrically neutral, the ionic balance % (U), is equal to the absolute difference between total of cations and anions concentration on total for these concentrations in epm, and calculated using Eqs. (2,3) [22,23]. When U≤5, the result could be accepted, but if 5<U≤10 the result will be accepted with risk [24].

$$U = (r\sum \text{cations} - r\sum \text{anions}/r\sum \text{cations} + r\sum \text{anions})x100 \tag{2}$$

$$A = 100 - U \tag{3}$$

Where; U, is the uncertainty; r is a value in equivalent per mile (epm), and A is the certainty or accuracy.

As shown in Table (5), the ionic balance of nearly all and Raw samples are < 5%. Which indicates that there is an electro-neutrality, i.e the concentration of negative and positive ions is nearly similar with nearly 100% certainty [22, 25]. So, the accuracy of the results could be used and dependent on it in hydrochemical interpretation [24].

2- Measured TDS and Conductivity Ratio

The TDS_m – to - EC ratio could be used to determine the analyses' correctness and instruments' accuracy and the standard ratio ranges from 0.55 to 0.7. If it is out, then either TDS or conductivity is suspect and needs to re-analyze [5]. The results in Table (5) reveals that all samples are within limit, i.e. accurate & accepted.

Table (5); ionic balance, accuracy and TDSm-to-EC ratio

Item	1A	1B	2A	2B	3A	3B	4A	4B	5A	5B	6A	6B	7A	7B	8A	8B	9A	9B	10A
Σ Anions	25.18	46.21	26.792	29.57	20.61	47.353	10.85	13.2	21.37	19.69	20.44	23.267	13.451	12.453	30.256	15.51	22.62	18.27	13.87
Σ cations	24.85	48.98	27.37	32.09	20.42	48.23	10.71	13.96	21.15	21.08	14.95	24.84	13.3	13.4	30.98	14.74	28.35	18.09	14.95
Σ Cat+ Σ Ani	50.03	95.19	54.162	61.66	41.03	95.583	21.56	27.16	42.52	40.77	35.39	48.107	26.751	25.853	61.236	30.25	50.97	36.36	28.82
Σ cat-Σ Ani	-0.33	2.77	0.578	2.52	-0.19	0.877	-0.14	0.76	-0.22	1.39	-5.49	1.573	-0.151	0.947	0.724	-0.77	5.73	-0.18	1.08
ionic balance	-0.0066	0.0291	0.0106	0.0409	-0.005	0.009	-0.006	0.028	-0.0051	0.034	-0.155	0.0327	-0.005	0.037	0.012	-0.025	0.112	-0.005	0.037
U	-0.66	2.91	1.067	4.087	-0.46	0.917	-0.65	2.798	-0.517	3.409	-15.5	3.27	-0.56	3.663	1.18	-2.54	11.24	-0.495	3.75
A	100.6	97.1	98.9	95.9	100.46	99.08	100.65	97.20	100.51	96.59	115.5	96.73	100.56	96.34	98.81	102.5	88.76	100.5	96.25
TDSm/EC	0.64	0.64	0.63	0.64	0.64	0.64	0.64	0.64	0.64	0.63	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.63

Table (5) ; continued

Item	10B	11A	11B	12A	12B	13A	13B	14A	14B	15A	15B	16A	17A	18A	19A	19B	20A	20B	Raw
Σ Anions	28.44	20.79	24.16	16.69	27.41	39.71	42.42	49.97	39.49	13.86	15.86	21.98	12.464	11.87	11.42	17.81	10.21	14.15	47.01
Σ cations	30.39	20.48	25.89	16.39	27.04	39.64	39.32	46.58	37.78	14.09	15.9	22.39	12.31	11.72	11.49	19.08	10.14	15.07	42.93
Σ ca+Σ An	58.83	41.27	50.05	33.08	54.45	79.35	81.74	96.55	77.27	27.955	31.763	44.37	24.774	23.59	22.914	36.892	20.353	29.219	89.94
Σ ca-Σ An	1.95	-0.31	1.73	-0.3	-0.37	-0.07	-3.1	-3.39	-1.71	0.225	0.037	0.41	-0.154	-0.15	0.066	1.268	-0.073	0.921	-4.08
ionic balance	0.033	-0.0075	0.0345	-0.009	-0.0068	-0.0008	-0.0379	-0.0351	-0.022	0.008	0.001	0.009	-0.006	-0.006	0.003	0.034	-0.0036	0.0315	-0.045
U	3.31	-0.75	3.45	-0.9	-0.68	-0.08	-3.79	-3.51	-2.2	0.80	0.1	0.9	-0.6	-0.6	0.3	3.4	-0.36	3.15	-4.5
A	96.69	100.75	96.54	100.9	100.68	100.08	103.79	103.51	102.2	99.2	99.9	99.1	100.6	100.6	99.7	96.6	100.36	96.85	104.5
TDSm/EC	0.64	0.64	0.64	0.64	0.64	0.6	0.65	0.65	0.65	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.61

3.4. Hydrochemical Properties

1.Hydrochemical formula (Kurolov formula) and water type

Kurolov formula and water type was determined for results Tables (2, 4) using Eq. (1),as shown in Table (6).

Table (6): Hydrochemical formula

tem	Cl epm%	HCO_3 epm%	SO_4 epm%	Ca epm%	K epm%	Mg epm%	Na epm%	Hydrochemical Formula	Water type	Pred. salts	No. &%
1A	66.3	17.9	15.7	15.3	2.21	8.45	74	1625 (Cl(66.3%)HCO3(17.9%)SO4(15. Na(74%)Ca(15.3%)8.3	(Ca-Sodium-SO_4-HCO_3-Chloride)	NaCl	(1)2.7
8A	65.7	12.84	21.4	24.85	0.26	11.62	63.26	1997 (Cl(65.7%)SO4(21.4%) /Na(63.27%)Ca(24.8%) 7.3	(Ca-Sodium-SO_4-Chloride)	NaCl	(1)2.7
1B	80.7	6.41	12.9	18.7	0.26	2.45	78.6	3187 Cl(80.7%) /Na(78.6%)Ca(18.7%) 7.75	(Ca-Sodium-Chloride)	NaCl	(6) 16.21
3B	84.5	8.3	7.18	17.73	0.41	9.7	72.15	3283 (Cl(84.5%) /Na(72.1%)Ca(17.7%) 7.55	(Ca-Sodium-Chloride)	NaCl	
13A	82.6	4.71	12.68	20.18	0.3	12.66	66.85	2400(Cl(82.6%) /Na(66.8%)Ca(20.2%)) 76.5	(Ca-Sodium-Chloride)	NaCl	
13B	84.9	5.76	9.29	19.45	0.38	12.77	67.4	2707(Cl(84.9%) /Na(67.4%)Ca(19.4%)7.9	(Ca-Sodium-Chloride)	NaCl	
14A	83.2	2.83	13.89	19.64	0.28	12.88	67.2	3280 (Cl(83.2%) /Na(67.2%)Ca(19.6%) 7.7	(Ca-Sodium-Chloride)	NaCl	
14B	83.6	6.33	10	18	0.4	10.67	70.94	2652(Cl(83.6%) /Na(70.9%)Ca(18%))7.8	(Ca-Sodium-Chloride)	NaCl	
2A	78.4	9.2	12.4	13.1	0.29	7.27	79.3	1720 (Cl(78.4%)/Na(79.3%)8.4	(Sodium-Chloride)	NaCl	(4) 10.81
9A	74.7	13	12.27	11.64	0.46	6.07	81.83	1829 (Cl(74.7%)/Na(81.8%))7.67	(Sodium-Chloride)	NaCl	
11B	77.2	13.3	9.5	12.4	0.7	5.4	81.5	1669 (Cl(77.2%)/Na(81.5%))7.05	(Sodium-Chloride)	NaCl	
12B	77.5	14.55	7.93	8.91	0.55	10.28	80.25	1881(Cl(77.5%)/Na(80.2%))7.74	(Sodium-Chloride)	NaCl	
2B	78.8	15.5	5.67	11.62	0.4	3.83	84.1	2112 (Cl(78.8%)HCO3(15.5%) /Na(84.1%)7.71	(Sodium-HCO_3-Chloride)	NaCl	(19) 51.35
3A	77.7	18.2	4.09	11.5	0.49	9.1	78.8	1231 (Cl(77.7%)HCO3(18.2%) /Na(78.8%)8.3	(Sodium-HCO_3-Chloride)	NaCl	
4A	54.4	41.3	4.23	7.93	0.75	10.1	81.23	663 (Cl(54.4%)HCO3(41.3%) /Na(81.2%)8.4	(Sodium-HCO_3-Chloride)	NaCl	
4B	67.1	28.8	4.06	7.16	0.71	4.73	87.39	925 (Cl(67.1%)HCO3(28.8%) /Na(87.4%))8.34	(Sodium-HCO_3-Chloride)	NaCl	
5B	72.4	18.8	8.72	14.2	0.71	5.83	79.2	1641 (Cl(72.4%)HCO3(18.8%) /Na(79.2%)7.59	(Sodium-HCO_3-Chloride)	NaCl	
6A	66.3	27.1	6.5	11.37	0.94	5.42	82.3	1114 (Cl(66.3%)HCO3(27.1%) /Na(82.3%)8.4	(Sodium-HCO_3-Chloride)	NaCl	
7A	58.5	39.6	1.86	5.41	0.6	6.01	87.97	846 (Cl(58.5%)HCO3(339.6%) /Na(87.97%))7.85	(Sodium-HCO_3-Chloride)	NaCl	
7B	58. 8	37.51	3.69	9.18	0.74	8.73	81.34	891(Cl(58.8%)HCO3(37.5%) /Na(81.3%)) 8.02	(Sodium-HCO_3-Chloride)	NaCl	
8B	67.7	27.31	4.96	8.82	0.54	4.48	86.16	996 (Cl(67.7%)HCO3(27.3%) /Na(86.16%))7.88	(Sodium-HCO_3-Chloride)	NaCl	
9B	58.8	36.9	4.28	10.37	1.2	5.48	82.94	940 (Cl(58.8%)HCO3(36.9%) /Na(82.9%))7.75	(Sodium-HCO_3-Chloride)	NaCl	
10A	63.2	29.64	7.11	14.92	0.33	6.24	78.51	1104(Cl(63.2%)HCO3(29.64%) /Na(78.5%))8.39	(Sodium-HCO_3-Chloride)	NaCl	
10B	76.9	14.99	8.08	13.26	0.43	4.05	82.26	1910 (Cl(76.9%)HCO3(15%) /Na(82.2%)7.82	(Sodium-HCO_3-Chloride)	NaCl	
15A	66.5	24.22	9.23	10.64	0.71	2.06	86.6	943 (Cl(66.5%)HCO3(24.2%) /Na(86.6%))8.1	(Sodium-HCO_3-Chloride)	NaCl	
17A	56.1	38.12	5.7	8.28	0.4	6.82	84.48	821 (Cl(56.1%)HCO3(38.1%) /Na(84.5%)) 7.94	(Sodium-HCO_3-Chloride)	NaCl	
18A	64.4	29.63	5.96	12.46	0.43	11.43	75.68	740 (Cl(64.4%)HCO3(29.6%) /Na(75.7%))8.38	(Sodium-HCO_3-Chloride)	NaCl	
19A	61.4	32.14	6.43	12.01	0.26	12.01	75.72	749 (Cl(61.4%)HCO3(32.14%) /Na(75.7%))8.46	(Sodium-HCO_3-Chloride)	NaCl	
19B	67.4	25.32	7.3	9.17	0.42	6.03	84.38	1224 (Cl(67.4%)HCO3(25.3%) /Na(84.4%))7.89	(Sodium-HCO_3-Chloride)	NaCl	
20A	44.2	43.56	12.17	12.82	0.3	11.93	74.95	643 (Cl(44.2%)HCO3(43.56%) /Na(74.9%))8.33	(Sodium-HCO_3-Chloride)	NaCl	
20B	67.1	26.8	6.01	10.95	0.53	4.91	83.61	966 (Cl(67.1%)HCO3(26.8%) /Na(83.6%))7.6	(Sodium-HCO3-Chloride)	NaCl	
5A	68.6	19.8	11.6	15.41	0.38	6.19	78	1319 (Cl(68.6%)HCO3(19.8%) /Na(78%)Ca(15.4%))8.37	(Ca-Sodium-HCO3-Chloride)	NaCl	(6+raw) 16.21
6B	69.8	15.2	14.92	15.5	1.13	7.29	76.1	1651 (Cl(69.8%)HCO3(15.2%) /Na(76.1%)Ca(15.5%) 7.61	(Ca-Sodium-HCO3-Chloride)	NaCl	
11A	69.97	19.92	10.1	18.65	0.63	6.49	74.22	1356 (Cl(69.97%)HCO3(19.92%) /Na(74.2%)Ca(18.65%))7.89	(Ca-Sodium-HCO3-Chloride)	NaCl	
12A	64.5	23.7	11.76	18.97	0.43	13.48	67.11	1081(Cl(64.5%)HCO3(23.7%) /Na(67.1%)Ca(18.97%)) 7.81	(Ca-Sodium-HCO3-Chloride)	NaCl	
15B	60.5	33.67	5.8	16.35	0.63	6.29	76.73	1182 (Cl(60.5%)HCO3(33.67%) /Na(76.73%)Ca(16.3%))7.87	(Ca-Sodium-HCO3-Chloride)	NaCl	
16A	69	17.71	13.25	24.56	0.45	14.69	60.3	1404(Cl(69%)HCO3(17.7%) /Na(60.3%)Ca(24.5%))7.45	(Ca-Sodium-HCO3-Chloride)	NaCl	
Raw	70.8	17.91	11.26	27.72	2.37	9.57	60.33	2858 (Cl(70.8%)HCO3(179%)/ Na(60.3%)Ca(27.7%))7.38*	(Ca-Sodium-HCO3-Chloride)	NaCl	

Kurolov formula showed that there are six hydrochemical formula in the study area and the predominant salt is NaCl, sodium chloride water type, as shown in Table (7) the six hydrochemical formula are:

Sodium-HCO_3^-Chloride ***51.35%***
Ca-Sodium-HCO_3-Chloride ***16.21%***
Ca-Sodium- Chloride ***16.21%***
Sodium-Chloride10.81%
Ca-Sodium-SO_4-HCO_3-Chloride ***2.7 %***
Ca-Sdium-SO_4-Chloride ***2.7%***

2.Hypothetical Salts

Water hypothetical salts for results in Table(4) were calculated by correlation between anions and cations Table(7).

Table (7); Hypothetical salts for water samples of study area

Hypothetical salts	1A	1B	2A	2B	3A	3B	4A	4B	5A	5B	6A	6B	7A	7B	8A	8B	9A	9B	10A	10B
KCl	2.21	0.26	0.29	0.4	0.49	0.41	0.75	0.71	0.38	0.71	0.94	1.13	0.6	0.74	0.26	0.54	0.46	1.2	0.33	0.43
NaCl	64.09	78.6	78.11	78.4	77.21	72.15	53.65	66.39	68.22	76.69	65.36	68.67	57.9	58.06	63.26	67.16	74.24	57.6	62.87	76.47
$MgCl_2$	0.0	1.84	0.0	0.0	0.0	9.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.18	0.0	0.0	0.0	0.0	0.0
$CaCl_2$	0.0	0.0	0.0	0.0	0.0	2.24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$K_2 SO_4$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$Na_2 SO_4$	9.91	0.0	1.19	5.67	1.59	0.0	4.23	4.06	9.78	2.51	6.5	7.43	1.86	3.69	0.0	4.96	7.59	4.28	7.11	5.79
$Mg SO_4$	5.79	0.61	11.21	0.0	2.5	0.0	0.0	0.0	1.82	5.83	0.0	7.29	0.0	0.0	9.44	0.0	4.68	0.0	0.0	2.29
$CaSO_4$	0.0	12.29	0.0	0.0	0.0	7.18	0.0	0.0	0.0	0.38	0.0	0.2	0.0	0.0	11.96	0.0	0.0	0.0	0.0	0.0
$NaHCO_3$	0.0	0.0	0.0	0.03	0.0	0.0	23.35	16.94	0.0	0.0	10.44	0.0	28.21	19.59	0.0	14.04	0.0	21.06	8.53	0.0
$Mg(HCO_3)_2$	2.66	0.0	0.0	3.83	6.6	0.6	10.1	4.73	4.37	0.0	5.42	0.0	6.01	8.73	0.0	4.48	1.39	5.48	6.24	1.76
$Ca(HCO_3)_2$	15.24	6.41	5.26	11.62	11.5	8.3	7.85	7.13	15.41	13.82	11.24	15.2	5.38	9.18	12.84	8.79	11.61	10.36	14.87	13.23

Table (7): continued

Hypothetical salts	10B	11A	11B	12A	12B	13A	13B	14A	14B	15A	15B	16A	17A	18A	19A	19B	20A	20B	Raw*
KCl	0.43	0.63	0.7	0.43	0.55	0.3	0.38	0.28	0.4	0.71	0.63	0.45	0.4	0.43	0.26	0.42	0.3	0.53	2.37
NaCl	76.47	69.34	76.5	64.07	76.95	66.85	67.4	67.2	70.94	65.79	59.87	60.3	55.7	63.97	61.14	66.98	43.9	66.57	60.33
$MgCl_2$	0.0	0.0	0.0	0.0	0.0	12.66	12.77	12.88	10.67	0.0	0.0	8.25	0.0	0.0	0.0	0.0	0.0	0.0	8.1
$CaCl_2$	0.0	0.0	0.0	0.0	0.0	2.79	4.35	2.84	1.59	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$K_2 SO_4$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$Na_2 SO_4$	5.79	4.88	5.0	3.04	3.3	0.0	0.0	0.0	0.0	9.23	5.8	0.0	5.7	5.96	6.43	7.3	12.17	6.01	0.0
$Mg SO_4$	2.29	5.22	4.5	8.72	4.63	0.0	0.0	0.0	0.0	0.0	0.0	6.44	0.0	0.0	0.0	0.0	0.0	0.0	1.47
$CaSO_4$	0.0	0.0	0.0	0.0	0.0	12.68	9.29	13.89	10	0.0	0.0	6.81	0.0	0.0	0.0	0.0	0.0	0.0	9.79
$NaHCO_3$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.58	11.06	0.0	23.08	5.75	8.15	10.01	18.88	11.03	0.0
$Mg(HCO_3)_2$	1.76	1.27	0.9	4.76	5.65	0.0	0.0	0.0	0.0	2.06	6.29	0.0	6.82	11.43	12.01	6.03	11.93	4.91	0.0
$Ca(HCO_3)_2$	13.23	18.65	12.4	18.94	8.9	4.71	5.76	2.83	6.33	10.58	16.32	17.71	8.22	12.45	11.98	9.17	12.75	10.86	17.91

The combination between major anions and cations reveals the formation of seven assemblages of hypothetical salts combinations as shown in Tables (7, 8). About 45.95% of the groundwater samples are characterized by assemblage I, about 24.3% are characterized by assemblage II, and about 10.8%characterized by assemblage III and about 8.1% and raw sample are characterized by assemblage IV. They are characterized by the presence of NaCl, Na_2SO_4, $NaHCO_3$, $Mg(HCO_3)_2$ and $Ca(HCO_3)_2$; NaCl, Na_2SO_4, $MgSO_4$, $Mg(HCO_3)_2$ and $Ca(HCO_3)_2$; NaCl, $MgCl_2$, $CaCl_2$, $CaSO_4$, and $Ca(HCO_3)_2$ and; NaCl, $MgCl_{2,}$ $MgSO_{4,}$ $CaSO_4$, and $Ca(HCO_3)_2$salts respectively. Assemblages V characterize about 5.4% of the groundwater samples is characterized by the presence of NaCl, Na_2 SO_4, $MgSO_4$, $CaSO_4$ and $Ca(HCO_3)_2$. Finally; each of assemblages VI and VII characterize about 2.7 % of samples are characterized by hypothetical salt assemblage (III) NaCl, $MgCl_2$, $CaCl_2$, $CaSO_4$, $Mg(HCO_3)_2$ and $Ca(HCO_3)_2$ and; NaCl, Na_2SO_4, $MgSO_4$, and $Ca(HCO_3)_2$respectively. Assemblages NaCl, $MgCl_2$, $CaCl_2$, $CaSO_4$, and $Ca(HCO_3)_2$, in water samples 13A, 13B, 14A and14B (localized in east side of the site) which is similar to that of Nile water and forms only 10.8%, which confirms that the recharge from River Nile in this region is very week .Generally, the aquifer in this region is not belongs to the river Nile aquifer, Table (8).The presence of marine salts of NaCl, Na_2SO_4 and $MgSO_4$ and $CaSO_4$ is may be due to the flushing of salt water by fresh water through local heavy infiltration of rainwater in the past pluvial times. The long–term contact time between rock matrix and water also, due to the dissolution of these salts encountered in the quaternary and pliocene water bearing sediments [11].

Table (8); Assemblages of hypothetical salts for wells and raw water samples of study area

Assemblages of hypothetical salts combinations	Classifi-cation	Sample no.	Number	%
NaCl, Na2 SO4, NaHCO3, Mg(HCO3)2, Ca(HCO3)2	I	2B, 4A, 4B, 6A, 7A, 7B, 8B, 9B, 10A, 15A, 15B, 17A, 18A, 19A, 19B, 20A, 20B	17	45.95
NaCl, Na2 SO4, Mg SO4, Mg(HCO3)2, Ca(HCO3)2	II	1A, 3A, 5A, 9A, 10B,11A, 11B, 12A, 12B	9	24.3
NaCl, MgCl2, CaCl2, CaSO4, Ca(HCO3)2,	III	13A, 13B, 14A, 14B, (localized in East side)	4	10.8
NaCl, MgCl2, Mg SO4, CaSO4, Ca(HCO3)2	IV	1B, 8A, 16A, and (Raw)	3	8.1
NaCl, Na2 SO4, Mg SO4, CaSO4, Ca(HCO3)2	V	5B,6B	2	5.4
NaCl, MgCl2, CaCl2, CaSO4, Mg(HCO3)2,Ca(HCO3)2,	VI	3B	1	2.7
NaCl, Na2 SO4, Mg SO4, Ca(HCO3)2	VII	2A	1	2.7
NaCl, Na_2 SO_4, Mg SO_4, $Mg(HCO_3)_2$, $Ca(HCO_3)_2$	II	1A, 3A, 5A, 9A, 10B,11A, 11B, 12A, 12B	9	24.3
NaCl, $MgCl_2$, $CaCl_2$, $CaSO_4$, $Ca(HCO_3)_2$.	III	13A, 13B, 14A, 14B, (localized in East side)	4	10.8
NaCl, $MgCl_2$, Mg SO_4, $CaSO_4$, $Ca(HCO_3)_2$	IV	1B, 8A, 16A, and (Raw)	3	8.1
NaCl, Na_2 SO_4, Mg SO_4, $CaSO_4$, $Ca(HCO_3)_2$	V	5B,6B	2	5.4
NaCl, $MgCl_2$, $CaCl_2$, $CaSO_4$, $Mg(HCO_3)_2$,$Ca(HCO_3)_2$.	VI	3B	1	2.7
NaCl, Na_2 SO_4, Mg SO_4, $Ca(HCO_3)_2$	VII	2A	1	2.7

3.Hydrochemical Indicators

Hydrochemical indicators ratios between the different major ions,Table (5), as; rCa/rCl, rCa/rMg, rMg/rCl, rNa/rCl, rK/rCl, rSO_4/rCl, rNa+rK/rCl, $rHCO_3$/rCl and (rNa+rK)-rCl/rSO_4, were calculated, **Table (9).**

Table (9)Average of hydrochemical indicators for water sample.

Item	1A	1B	2A	2B	3A	3B	4A	4B	5A	5B	6A	6B	7A	7B	8A	8B	9A	9B	10A	10B
rK/rCl	0.034	0.003	0.004	0.006	0.007	0.005	0.015	0.012	0.006	0.011	0.011	0.017	0.010	0.014	0.004	0.009	0.008	0.022	0.005	0.006
rNa/rCl	1.13	1.04	1.03	1.16	1.06	0.87	1.61	1.42	1.15	1.18	0.95	1.17	1.49	1.49	1.02	1.39	1.41	1.53	1.27	1.15
rCa/rCl	0.23	0.25	0.17	0.16	0.16	0.21	0.16	0.12	0.23	0.21	0.13	0.24	0.09	0.17	0.40	0.14	0.20	0.19	0.24	0.18
rMg/rCl	0.13	0.03	0.09	0.05	0.12	0.12	0.20	0.08	0.09	0.09	0.06	0.11	0.10	0.16	0.19	0.07	0.10	0.10	0.10	0.06
rCa/rMg	1.81	7.63	1.81	3.03	1.27	1.83	0.79	1.52	2.49	2.44	2.10	2.13	0.90	1.05	2.14	1.97	1.92	1.89	2.39	3.28
rMg/rCa	0.55	0.13	0.55	0.33	0.79	0.55	1.27	0.66	0.40	0.41	0.48	0.47	1.11	0.95	0.47	0.51	0.52	0.53	0.42	0.31
rSO_4/rCl	0.24	0.16	0.16	0.07	0.05	0.09	0.08	0.06	0.17	0.12	0.10	0.21	0.03	0.06	0.33	0.07	0.16	0.07	0.11	0.11
rNO_3/rCl	0.01	0.001	0.001	0.01	0.01	0.001	0.001	0.01	0.01	0.01	0.01	0.01	0.001	0.001	0.06	0.22	0.03	0.01	0.01	0.001
$rHCO_3/rCl$	0.27	0.08	0.12	0.20	0.23	0.10	0.76	0.43	0.29	0.26	0.41	0.22	0.68	0.64	0.20	0.40	0.17	0.63	0.47	0.19
$(Ca+Mg)/HCO_3$	1.34	3.51	2.27	1.09	1.19	3.35	0.47	0.45	1.11	1.15	0.48	1.61	0.29	0.51	3.01	0.53	1.75	0.47	0.73	1.24
(rNa+rK)/rCl	1.16	1.04	1.04	1.17	1.07	0.88	1.63	1.43	1.16	1.19	0.96	1.19	1.50	1.50	1.03	1.40	1.41	1.55	1.27	1.15
$Cl/ CO_3+ HCO_3$	3.31	12.61	8.54	5.09	3.43	10.13	1.07	2.14	3.14	3.85	2.10	4.59	1.47	1.57	5.12	2.48	5.75	1.59	1.98	5.13
Water Origin	Met.	Met.	Met.	Met.	Met.	Mar.	Met.	Met.	Met.	Met.	Mar.	Met.	Met.	Met.	Met.	Met.	Met.	Met.	Met.	Met.
CAI-1	-0.16	-0.04	-0.04	-0.17	-0.07	0.13	-0.63	-0.43	-0.16	-0.19	0.04	-0.19	-0.50	-0.50	-0.03	-0.40	-0.41	-0.55	-0.27	-0.15
CAI-2	-0.30	-0.16	-0.13	-0.62	-0.18	0.68	-0.62	-0.80	-0.32	-0.48	0.06	-0.43	-0.70	-0.72	-0.04	-0.57	-1.12	-0.78	-0.43	-0.50

Table (9); continued

Item	1A	1B	2A	2B	3A	3B	4A	4B	5A	5B	6A	6B	7A	7B	8A	8B	9A	9B	10A	10B
rK/rCl	0.034	0.003	0.004	0.006	0.007	0.005	0.015	0.012	0.006	0.011	0.011	0.017	0.010	0.014	0.004	0.009	0.008	0.022	0.005	0.006
rNa/rCl	1.13	1.04	1.03	1.16	1.06	0.87	1.61	1.42	1.15	1.18	0.95	1.17	1.49	1.49	1.02	1.39	1.41	1.53	1.27	1.15
rCa/rCl	0.23	0.25	0.17	0.16	0.16	0.21	0.16	0.12	0.23	0.21	0.13	0.24	0.09	0.17	0.40	0.14	0.20	0.19	0.24	0.18
rMg/rCl	0.13	0.03	0.09	0.05	0.12	0.12	0.20	0.08	0.09	0.09	0.06	0.11	0.10	0.16	0.19	0.07	0.10	0.10	0.10	0.06
rCa/rMg	1.81	7.63	1.81	3.03	1.27	1.83	0.79	1.52	2.49	2.44	2.10	2.13	0.90	1.05	2.14	1.97	1.92	1.89	2.39	3.28
rMg/rCa	0.55	0.13	0.55	0.33	0.79	0.55	1.27	0.66	0.40	0.41	0.48	0.47	1.11	0.95	0.47	0.51	0.52	0.53	0.42	0.31
rSO_4/rCl	0.24	0.16	0.16	0.07	0.05	0.09	0.08	0.06	0.17	0.12	0.10	0.21	0.03	0.06	0.33	0.07	0.16	0.07	0.11	0.11
rNO_3/rCl	0.01	0.001	0.001	0.01	0.01	0.001	0.001	0.01	0.01	0.01	0.01	0.01	0.001	0.001	0.06	0.22	0.03	0.01	0.01	0.001
$rHCO_3/rCl$	0.27	0.08	0.12	0.20	0.23	0.10	0.76	0.43	0.29	0.26	0.41	0.22	0.68	0.64	0.20	0.40	0.17	0.63	0.47	0.19
$(Ca+Mg)/HCO_3$	1.34	3.51	2.27	1.09	1.19	3.35	0.47	0.45	1.11	1.15	0.48	1.61	0.29	0.51	3.01	0.53	1.75	0.47	0.73	1.24
(rNa+rK)/rCl	1.16	1.04	1.04	1.17	1.07	0.88	1.63	1.43	1.16	1.19	0.96	1.19	1.50	1.50	1.03	1.40	1.41	1.55	1.27	1.15
$Cl/ CO_3+ HCO_3$	3.31	12.61	8.54	5.09	3.43	10.13	1.07	2.14	3.14	3.85	2.10	4.59	1.47	1.57	5.12	2.48	5.75	1.59	1.98	5.13
Water Origin	Met.	Met.	Met.	Met.	Met.	Mar.	Met.	Met.	Met.	Met.	Mar.	Met.	Met.	Met.	Met.	Met.	Met.	Met.	Met.	Met.
CAI-1	-0.16	-0.04	-0.04	-0.17	-0.07	0.13	-0.63	-0.43	-0.16	-0.19	0.04	-0.19	-0.50	-0.50	-0.03	-0.40	-0.41	-0.55	-0.27	-0.15
CAI-2	-0.30	-0.16	-0.13	-0.62	-0.18	0.68	-0.62	-0.80	-0.32	-0.48	0.06	-0.43	-0.70	-0.72	-0.04	-0.57	-1.12	-0.78	-0.43	-0.50

Chloride ion used to know the geochemical behavior for main elements by the ratio of main elements to chloride because (Cl-) is the most dissolve ion and less influenced by physical and chemical changes in water. In addition, it is not influenced by adsorption process and exchange of ion by the clay minerals [13]. If the indicators are greater than one then the water is from meteoric origin and less than one is for water from marine origin [9]

Hydrochemical indicators' ratios, Table (9) as; rNa/rCl range between 0.75 in well no 13B and 1.76 in well no. 20A. that ratio of 81.1% of samples and raw water are >1 and of meteoric origin and 18.9% are <1 i.e. indicating halide dissolution. Also, it can be attributed to the existence of a deep recharge from the deeper aquifers in these wells, so it is of marine origin as reported [9].The rK/rCl ratios range between 0.003 in well no.1B, and 14A, and 0.034 in well no.1A, also it is 0.031 in raw water sample. A ratio of 94.6% of samples are < 0.019 that excludes addition of K from fertilizer application and other anthropogenic activities. And the original source of Na and K ions are the dissolution of halite (NaCl) and sylvite (KCl) minerals [9]. rMg/rCl ratios range between 0.03 in well no.1B and 0.28 in well no. 20A, also it is a 0.13 in raw water sample. A ratio of 64.9% of samples and raw water are > 0.1 and are of meteoric origin [26]. rCa/rCl ratio range between 0.092 in well no.7A and 0.37 in well no.16A, also it is a 0.36 in raw water sample and that ratio of 100% of well samples and raw water are >0.02, and are of meteoric origin [26]. The values of hydrochemical coefficient rSO_4/rCl range between 0.03 in well no.7A and 0.33 in well no. 8A, also it is a 0.16 in raw water sample and that ratio of 97.4% of well and raw water > 0.05 are of meteoric origin. High value of this coefficient is mainly due to the dissolution processes of local terrestrial sulphate minerals present in aquifer materials [26]. rNO_3/rCl ratios range between 0.001 in 14wells and 0.22 in well no. 8B, also it is a 0.01 in raw water sample and that a ratio of 100% of samples and raw water are of meteoric origin as the rNO_3/rCl ratio $>1.0x10^{-9}$[26]. The value of the coefficient $rHCO_3/rCl$ varies between 0.03 in well no: 14A, to 0.98 in well no.20A, also it is a 0.25 in raw water sample. And all samples have value <1 which indicates predominance of Cl over HCO_3 due to leaching process of chloride from its bearing minerals. The coefficient rCa/rMg shows high values varying from 0.79 in well no.4A, to 7.63 in well no.1B, with an average of 2.06, also it is a 2.9 in raw water sample, which is more related to rainwater value 3.08 than normal sea water 0.21, and confirms the meteoric water origin of the aquifer in the study area [11]. The coefficient rMg/rCa shows high values varying from 0.13 in well no.1B, to 1.27 in well no.4A, with an average of 0.61, also it is a 0.35 in raw water sample, when the Mg /Ca ratio value <1 then water is of meteoric origin [27]. The value of the coefficient $(rCa+rMg)/rHCO_3$ in the groundwater varies between 0.29 in well no. 7A to 10.9 in well no.14A, with an average of 1.81 in the area's groundwater. Also it is a 1.94 in raw water sample, and ratio of 83.78% of samples > 0.5, which could be attributed to depletion of HCO_3 in the aquifer systems, while a 16.2% <0.5 and those around 0.5 are 32.42% and its source of Ca and Mg are mainly from the carbonate minerals [28]. The value of the hydrochemical coefficient (rNa+rK)/rCl varies between 0.76 in well no. 13B to 1.76 in well no.20A, with an average of 1.196,also it is a 0.82 in raw water sample, and a ratio of 81.08% of samples >1, which indicate other sources of Na ions than halite and sylvite (KCl) minerals [29]. The value of the coefficient $rCl/(rHCO_3+rCO_3)$ in water samples have values vary between 0.92 in well No.20A and 29.14 in well. No. 14A, with an average value of 5.2, also it is a 3.65 in raw water sample. The wells are categorized into four categories; slightly contaminated water 27%, moderately contaminated water 54%, seriously contaminated water 13.5% and highly contaminated water 5.4% [30] as shown in **Table (10).**

Table (10): Wells samples classification

Category No.	I	II	III	IV
$rCl/(rHCO_3+rCO_3)$	1-2	2-6	6-15	15-200
Category description	Slightly contaminated water	Moderately contaminated water	Seriously contaminated water	Highly contaminated water
Wells No.	4A, 7A, 7B, 9B, 10A, 15B, 17A, 18A, 19A and 20A	1A, 2B,3A, 4B, 5A, 5B, 6A, 6B,8A, 8b, 9A, 10B, 11A, 11B, 12A, 12B, 15A, 16A, 19B,20B and Raw	1B,2A, 3B, 13B and 14B	13A and 14A

3.5. Index of Base Exchange

The ion exchange between the groundwater and its host environment during residence or travel were determined using data Table (4), by calculating the chloro-alkaline indices (CAI) [14, 15]. The two chloro-alkaline indices have been calculated as shown in Table (9) Both of CAI-1and CAI-2values indicate that 18.9% water samples are positive indicates a direct exchange, whereas 81.1% samples show reverse exchange (negative indices),i.e. the Ca and Mg ions dissolute from adjacent rocks to the water reverse forward reaction[20,31].

3.6. Groundwater Classification

For water classifications according to Piper, Durov and Schoeller, the results in Table (4) were subjected to Aquachem v3.7 software program was used and for determining the area's groundwater type.

1. Piper's Classification

The results in epm were plotted on piper's diagram and the resulted diagram was compared with Langguth Classification as shown in **Fig. (1).**

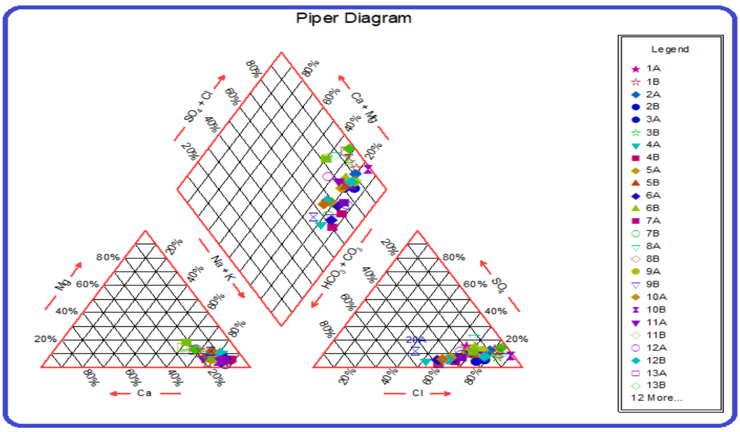

Figure (1); Piper's Classification Diagram

Piper interpretation is based on the major chemical elements of groundwater (Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, Cl^{-}, CO_3^{2-} HCO_3^{-}, SO_4^{2-}), to interpret general geochemical evolution pathways of groundwater in the study area. According to piper diagram, the projected onto the third diamond field of diagram was compared with Langguth classification revealed that all wells and raw water samples fall in field G and are alkaline water with prevailing of sulfate and chloride Na^{+}+ K^{+}–SO_4^{2-}– Cl^{-} type indicating halite weathering, as shown in Fig. (1). The dominant cation and anion of groundwater are Na and Cl, respectively, the predominant salts in water samples are (NaCl), (Na_2SO_4),($MgSO_4$) and ($CaSO_4$), this is confirmed by hypothetical salt combination as shown in Table(8) [32].

2. Durov's Classification

The results in epm were plotted on two ternary diagrams where; the cations values were plotted perpendicularly against those of anions; the sides of the triangles form a central rectangular as shown in **Fig. (2**

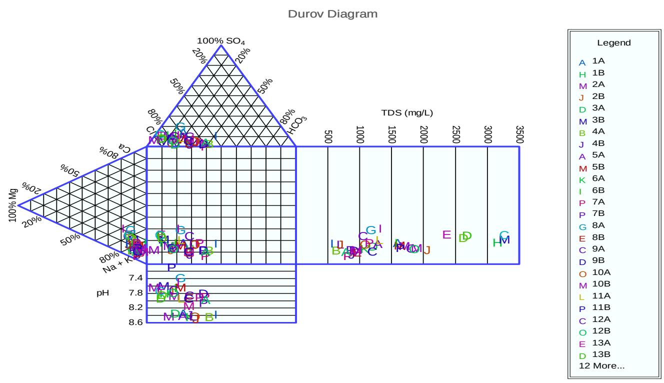

Figure (2); Durov's Classification Diagram

according to Lioyd and Heathcote division of Durov diagram all wells and raw water fall in two classes as shown in Fig. (2). Field 7; where, Cl^{-} and Na^{+} dominant frequently indicate end point down gradient waters through dissolution and, in Field 8; where, SO_4^{2-} dominates, or anion indiscriminate and Na^{+} dominant, is a water type not frequently encountered and indicates probable mixing or uncommon dissolution influences [16, 17].

3. Schoeller's Classification

Concentrations of major ions in epm, were plotted on Schoeller's diagram as shown in Fig. (3);

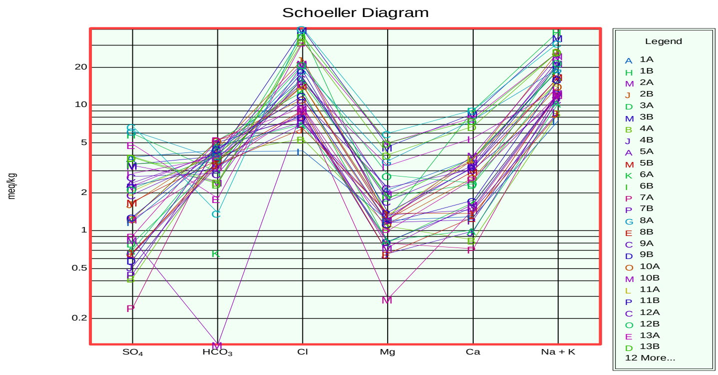

Figure (3);Schoeller's Classification Diagram

Schoeller's diagram revealed that the groundwater samples of the study area nearly had the same trend of major ion increase and decrease i.e. the similar waters exhibit similar "fingerprints" and all water samples with high Na content with also has high Cl content. The samples showed a different ionic composition that was dominated by Na^{+}, with cationic order of abundance $Na^{+} > Ca^{2+} > Mg^{2+}$ epm, and the anionic composition was dominated by $Cl^{-} > HCO_3^{-} > SO_4^{2-}$ epm,i.e, the chemical composition was characterized by the Na-Cl type as shown in Fig. (3)

4. Gibb's Classification

The results in Tables (2, 4) were subjected to Gibb's diagram and the results as shown in Table (11) Fig. (4).

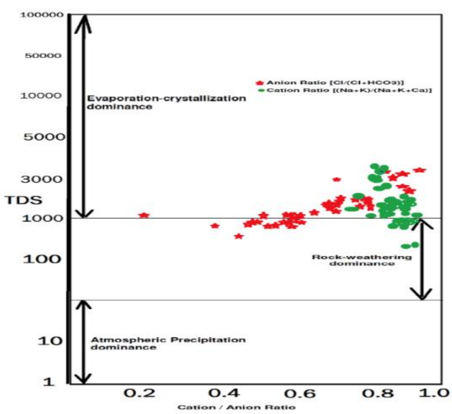

Figure (4); Gibb's Classification diagram

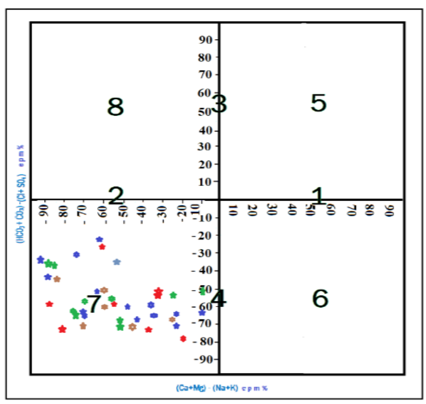

Figure (5); Chadha's diagram for study area water

5. Chadha's classification

It was constructed for the results in Table (4), by plotting the difference between alkaline earth and alkali metals and the difference between weak acidic anions and strong acidic anions in epm% as in Table (11) and **Fig. (5)**

Table (11); Chad ha classification's calculations

tItem	1A	1B	2A	2B	3A	3B	4A	4B	5A	5B	6A	6B	7A	7B	8A	8B	9A	9B	10A	10B	11A
$(HCO_3 + CO_3)$	19.51	6.40	9.20	15.40	21.50	8.34	46.40	30.41	21.31	18.70	30.10	15.10	39.60	37.50	12.40	23.80	12.70	36.6	30.90	15.00	19.70
$(Cl + SO_4)$	80.1	93.3	90.8	84.1	77.58	91.68	53.64	69.09	78.2	80.8	69.26	84	60.26	62.49	84.1	63.32	84.88	62.6	68.19	84.75	79.3
$(HCO_3 + CO_3) - Cl + SO_4)$	-60.59	-86.9	-81.6	-68.7	-56.1	-83.3	-7.24	-38.68	-56. 9	-62.1	-39.16	-68.9	-20.66	-24.99	-71.7	-39.52	-72.18	-26	-37.29	-69.75	-59.6
(Ca+Mg)	23.75	21.15	20.37	15.43	20.61	27.4	18.03	11.89	21.6	20.03	16.79	22.79	11.424	17.91	36.42	13.3	17.71	15.8	21.14	17.31	25.14
(Na+K)	76.21	78.865	79.59	84.505	79.29	72.51	81.95	88.116	78.38	79.91	83.236	77.23	88.57	82.09	63.53	86.703	82.26	84.1	78.83	82.62	74.835
(Ca+Mg) -(Na+K)	-52.46	-57.7	-59.2	-69.07	-58.7	-45.1	-63.92	-76.26	-56.8	-59.88	-66.446	-54.44	-77.15	-64.18	-27.1	-73.4	-64.5	-68.2	-57.69	-65.32	-49.7
TDS ppm	1625	3187	1720	2112	1231	3283	663	925	1319	1438	1114	1651	846	891	1997	996	1696	940	1104	1910	1356
$Cl/Cl+HCO_3$ epm	0.79	0.93	0.90	0.84	0.81	0.91	0.57	0.70	0.78	0.79	0.71	0.82	0.60	0.61	0.84	0.71	0.85	0.61	0.68	0.84	0.78
Na+K/Na+K+Ca epm	0.83	0.81	0.86	0.88	0.87	0.80	0.91	0.92	0.84	0.85	0.88	0.83	0.94	0.90	0.72	0.91	0.88	0.89	0.84	0.86	0.80

Table (11): continued

Item	11B	12A	12B	13A	13B	14A	14B	15A	15B	16A	17A	18A	19A	19B	20A	20B	Raw
$(HCO_3 + CO_3)$	13.20	23.50	14.50	4.88	5.91	2.80	6.56	23.60	33.60	17.50	38.10	34.34	37.06	25.30	45.90	26.80	19.05
$(Cl + SO_4)$	86.48	75.8	85.2	92.6	92.07	95.2	92.2	74	66.3	81.3	61.89	65.66	62.85	74.7	54	73.1	80.5
$(HCO_3 + CO_3) - Cl + SO_4)$	-73.28	-52.3	-70.7	-87.72	-86.16	-92.4	-85.64	-50.4	-32.7	-63.8	-23.79	-31.32	-25.79	-49.4	-8.1	-46.3	-61.45
(Ca+Mg)	17.8	32.47	19.21	32.9	32.1	32.5	28.7	12.66	22.59	39.2	15.1	23.8	24.01	15.2	24.7	15.81	37.27
(Na+K)	82.19	67.5	80.75	67.1	67.78	67.48	71.3	87.31	77.36	60.7	84.9	76.13	75.96	84.82	75.2	84.13	62.67
(Ca+Mg) -(Na+K)	-64.39	-35.06	-61.54	-34.2	-35.68	-34.98	-42.6	-74.65	-54.77	-21.55	-69.8	-52.33	-51.95	-69.62	-50.5	-68.32	-25.4
TDS ppm	1669	1081	1881	2400	2707	3280	2652	943	1182	1404	821	740	749	1224	643	966	2858
$Cl/Cl+HCO_3$ epm	0.85	0.73	0.84	0.95	0.94	0.97	0.93	0.73	0.64	0.80	0.60	0.68	0.66	0.73	0.50	0.71	0.80
Na+K/Na+K+Ca epm	0.87	0.78	0.90	0.77	0.78	0.77	0.80	0.89	0.83	0.71	0.91	0.86	0.86	0.90	0.85	0.88	0.69

Gibb's diagram showed that the distribution of sample points residing in the central part of the plot based on ratios of (Na+K)/(Na+K+Ca) and Cl/(Cl+HCO_3) as a function of TDS, reflected the supremacy of weathering of rocks with influence of evaporation crystallization in controlling geochemistry of water samples from the study area (Fig.4)[4]. None of samples lie in the lower side of the boomerang, where water composition is dominated by atmospheric precipitation process.

Chadha's diagram showed that most of samples fall in seventh sub-field of the diagram which reveals that alkali metals (Na, K) and strong acidic anions (Cl, SO_4) exceed over alkaline earths (Ca, Mg) and weak acidic anions (HCO_3), respectively Fig. (5). The positions of data points in the diagram represent Na–Cl^-–SO_4^{2-}type. The water of this type has high TDS value due to dissolution of soluble evaporated minerals such as halite and gypsum, and Na-Ca exchange reactions occurring between the groundwater and fined grain-sediments.

3.7. Hydrochemical Faces in the Study Area

Hydrochemical faces are a function of solution kinetics, rock-water interactions, geology and contamination sources, and are identified from Kurolov, Piper, Durov and Chadha diagrams and chebotarev [21, 33, 34, 35]. The Kurolov hydrochemical formula reveals that there are six hydrochemical formulas and the main water face is Na-Cl. But according a more distinct ways as; Chebotarev classification depending on TDS content, Table (2), the water type is ranges between HCO_3–Cl,fairly fresh water(F3), to Cl–SO_4face,slightly brackish water(B1).According Piper area's waters are alkaline water with prevailing of sulfate and chloride Na+K- SO_4+Cl face, also, according Durov Cl- SO_4- Na are dominant face, but according to Chadha Na-Cl-SO_4type is the prevailing face.

Conclusion

The hydrochemical class and water type of groundwater in West Assiut Electric Power Plant's area(with respect to the accurate and valid physiochemical and chemically related properties) are determined using the hydrochemical formulae's (Kurolov formula, hypothetical salts), hydrochemical indices and water type identification programs as Piper, Durov, Schoeller, Gibb, and Chadha were applied for deciding the water class and type. Kurolov formula showed six groups (assemblages) of salt combination, while combination between major anions and cations reveals the formation of seven assemblages of hypothetical salts combinations. Hydrochemical indicators' ratios revealed that the recharge from Nile River is very weak and may be a deep recharge from the deeper aquifers in these wells. The chloro-alkaline indices indicate that the major reaction is the dissolution of Ca and Mg to groundwater (negative indices) and the precipitation of sodium and potassium into the soil is the minor reaction (positive indices).According to Piper, area's groundwater are alkaline water with prevailing of sulfate and chloride Na+ K–SO_4+ Cl face, also, according to Durov Cl+ SO_4– Na are dominant face, also according to Chadha Na–Cl+SO_4type is the prevailing face. While Schoeller classified it to Na and Cl and the families are Na–Cl and Gibb reflected the supremacy of weathering of rocks with influence of evaporation crystallization in controlling geochemistry of groundwater in the study area.

The finding of the above work is useful for Determination of pollutants in the groundwater wells of the plant, and consequently the method of water treatment, which is chosen according to the type of use: for agriculture, irrigation, industrial and building Purposes, human drinking and livestock Purposes.

The research is useful in guiding orgiving an idea for those who want to use groundwater in the Western Desert region and the borders of the Assiut Governorate region on water components and how to treat .

References

1.Khan, Stuart J., Murchland, David, Rhodes, Michelle and Waite, T. David, **(2009),** "Management of Concentrated Waste Streams from High-Pressure Membrane Water Treatment Systems", *Critical Reviews in Environmental Science and Technology* **39**:5, 367 - 415.

2.Todd, D.K. (1980) Groundwater hydrology. 2nd ed,Wiley, New York.

3.Winter, Th. C., Harvey, J. W., Lehn Franke, O. and Alley, W. M., (1998) "Ground Water and Surface water A Single Resource, U.S.G.S. Circular 1139: **79**.

4.Ravikumar, P., Somashekar, R.K and Prakash, K.L. **(2015)** "A comparative study on usage of Durov and Piper diagrams to interpret hydrochemical processes in groundwater from SRLIS river basin," Karntaka, *India Available online at (Elixir International Journal) Earth Science Elixir Earth* Sci. 80, 31073-31077.

5.APHA (2017). (American Public Health Association), American water works association (AWWA) and Water Environmental Federation (WEF). Standard methods for the examination of water and wastewater, 23nd Edition.

6.APHA (1998). Standard Methods of the Examination of Water and Wastewater. 20th ed., Washington D.C., American Public Health Association.

7.APHA (2005) (American Public Health association)..Methods for the examination of water and wastewater, 21st edition.

8.Lind, O. T. (1979). Handbook at Common Methods in Limnology C.V. Mosby St. Louis.

9.Ivanov, V.V., Barbanov, L. N., and Plotnikova, G. N. (1968). The main genetic types of the earths crust mineral water and their distribution in the USSR. Inter. Geol. Cong. of 23rd. *Sessions Czechoslovakia* ,V. **12**.p33.

10. **Mohamed Yousif, Olaf Bubenzer, (2012)**"Perched groundwater at the northwestern coast of Egypt": a case study of the Fuka Basin. *Appl Water Sci* **2**:15–28.

11. **Mohamed kamel Fattah (2017)"**Evaluation of Water Resources in Wadi El Natrun, Western Desert, Egypt". International Journal of Environment, Agriculture and Biotechnology (IJEAB) Vol-2, *Issue-1, J an-Feb.*

12. **Collins, A. G. (1975) "**Ge chemistry of oil- field water." Development in Petroleum science, No.11, Elsevier, *Amsterdam, Holland, ,* **49**6p.

13. **Levy, D. B and Kearney** W. F. **(1974)** Irrigation of native rangeland using treated waste water from in situ uranium processing *J. Environ. Quality*. **28**, 208-217.

14. **Schoeller H. (1967)** Geochemistry of G. water. An international guide for research and practice, UNESCO, Chap.15,p1-

15. **Hedge, G. V., (2006)** Evaluation of chemical quality of groundwater resource in Dharward districts Karnataka. *Journal of Geological Society of India* **67**, p. 4-58.

16. **R. A. Akoachere, Y. M. Ngwese, S. E. Egbe, T. A. Eyong, S. N. Edimo, D. B. Tambe**, **(2018)** "Groundwater Monitoring in the Gneisso-Basaltic Fractured Rock Aqu ferous Formations of Kumba, Southwest Region Cameroon: Seasonal Variations in the Aqueous Geochemistry and Water Quality" Journal of *Geoscience and Environment Protection*, **6**, 18-50.
17. **Lloyd, J. A., & Heathcote, J. A., (1985)** "Natural Inorganic Hydrochemistry in Relation to Groundwater: An Introduction", *New York: Oxford University Press*, (p. **296**).
18. **Schoeller R.: Les eaux Souterraines, Msson and Cie**, Paris **(1962)**, **642**pp.
19. Gibb, R.,1971. Mechanism controlling world river water chemistry: vapor. - crystallize. process. Science **172**, 871–872.
20. **Chadha DKA**, **(1999)** "Proposed new diagram for geochemical classification of natural waters and interpretation of chemical data." *Hydrogeol J*, **7**(5):431-439.
21. **Chebotarev, I.I**., **(1955)**, "Metamorphism of natural water in the crust of weathering." *Geochim. Cosmochim. Acta*, v.**8**, pp.22-48, 137- 170, 198-212.
22. **Roger B. Baird, Andrew D. Eaton, Eugene W. Rice (2017)**, "standard methods for the examination of water wastewater", **23**rd Edition
23. **Hem, J.D., (1985)** "Study and interpretation of the chemical characteristics of natural water," 3rd. ed. U.S.G.S. *water supply paper*., **2254.** 263p.
24. **Al-Hamadani, J.A.,(2009).** Hydrochemical effect of ground water due to irrigation and drainage projects in Tawuq sub-Basin (*South of Karkuk North of Iraq).* Unpublished M.Sc. University of Baghdad, College of Science. **120pp**.
25. **Valerie B.Garcia, Katharine D., Katherine G., Andrew T.** "Treating Brackish Groundwater in Texas: A Comparison of Reverse Osmosis and Nanofiltration" Final Report Submitted to the Texas Water *Development Board, U.S. Department of the Interior Bureau of Reclamation*, May 2015.
26. **Mahmoud K., Corinne Le Gal La Salle, Joel L., ASTER team, Amad M., Patrick V., Aurelie N., Roland S., (2013)** "Origin of groundwater salinity (current seawater vs. saline deep water) in a coastal karst aquifer based on Sr and Cl isotopes. Case study of the La Clape massif (*southern France*)" *Applied Geochemistry* **37**-212–227

27. **Hem, J. D.,** (**1992)**. Study and Interpretation of *the Chemical Characteristics of Natural Water. U.S. Geological Survey Water-Supply Paper* **2254**.
28. **Rajmohan N and Elango L. (2004)** "Identification and evolution of hydrogeochemical processes in the groundwater environment in an area of the Palar and Cheyyar River Basins, Southern India". *Environ Geology,* ,**46**:47-61
29. **Hesham A. Ezzeldin, Ahmad Kamal, Aya M. Reda, Khairia Guindy and Ibrahim El-Shamy, (2018)**. "Assessment of Factors Affecting the Groundwater Quality in El-Hammam Area, North-West Coast of Egypt" Middle East Journal of Applied Sciences, Volume: 08- p **798-**819 | Issue :03 |July-Sept.|
30. **Mohamed el Alfy, Broder Merkel**, **(2006)** "Hydrochemical Relationships and Geochemical Modeling Of Ground Water In Al Arish Area, North Sinai, Egypt'', Journal of *American Institute of Hydrology, Hydrological Science and Technology,* **22(**1-4) 47-62.
31. **Freeze, R.A. and Cherry, G.E**. **(1979).** "*Groundwater. Prentice - Hall, Englewood Cliffs*", New Jersey, U.S.A, 460.
32. **Alassane, A., Trabelsi, R., Dovonon, L.F., Odeloui, D.J., Boukari, M., Zouari, K. and Mama, D. (2015)** Chemical Evolution of the Continental Terminal Shallow Aquifer in the South of Coastal Sedimentary Basin of Benin (West- Africa) Using Multivariate Factor Analysis. *Journal of Water Resource and Protection,* **7**, 496-515.
33. **Karanth K. R. (2008) "**G.water Assessment Development and Management" *Tata McGraw-Hill Offices,* New Delhi,p **720.**
34. **K. Srinivasamoorthy, M. Gopinath, S. Chidambaram, M. Vasanthavigar, V.S. Sarma, (2014)** "Hydrochemical characterization and quality appraisal of groundwater from Pungar sub basin, Tamilnadu, India, *Journal of King Saud University – Science* **26**, 37–52.
35. **Stevanovic Z. & Iurkiewicz A. (2009)** "G. water management in northern Iraq."*Hydrogeology* Journal, **17**:367-378.

الملخص العربي

التصنيف الهيدروكيميائي للمياه الجوفية في منطقة محطة كهرباء غرب اسيوط المركبة- أسيوط – مصر

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المياه الجوفية هي المصدر الرئيسي للمياه المستخدمة في محطة كهرباء غرب اسيوط المركبة، لذلك سوف نقوم بدراسة التصنيف الهيدروكيميائي ونوعية المياه الجوفية في منطقة محطة كهرباء غرب اسيوط المركبة ، وسيتم الاشارة الي تحاليل العناصر الفيز وكيميائية والكيميائية والخصائص الكيميائية

وكي نســتطيع ان نقرر تصنيف المياه الجوفية سنقوم بتطبيق الصيغ الهيدروكيميائية مثل صيغة كروبوف (**Kurolov formula**) والاملاح الافتراضية (**hypothetical salts**) و المؤشـرات الهيدروكيميائية (**hydrochemical indices**) وتطبييق برامج مثل بايبر(**Piper,**) ودورف (**Durov**) وشوللير (**Schoeller**) وجيب (**Gibb**) وشادا (**Chadha**) لتحديد نوع المياه. وتمكن البحث من تحديد الملوثات داخل مياه الابارالجوفية للمحطة وبالتالي تحديد طريقة معالجة المياه والتي يتم اختيارها علي حسب نوع استخدامها ، ويفيد البحث في توجيه أو إعطاء فطرة لمن يريد استخدام المياه الجوفية في منطقة الصحراء الغربية وحدود منطقة محافظة اسيوط علي مكونات المياه وكيفية معالجتها)