IOSR Journal of Applied Physics (IOSR-JAP)
e-ISSN: 2278-4861.Volume 9, Issue 5 Ver. II (Sep. - Oct. 2017), PP 34-46
www.iosrjournals.org

Impactof Geological and Hydrological Setting on Radon-222 Concentration of Groundwater from Luxor,Egypt.

*S. Harb[1], Karem. M. Moubark[2], Mahmoud A. Kilany[1], C. Walther[3]
[1] *ERML, Physics Department, Faculty of Science 83523 Qena, South Valley University, Egypt.*
[2]*Geology Department, Faculty of Science 83523 Qena, South Valley University, Egypt.*
[3] *Leibniz University Hanover, Institute for Radioecology and Radiation protection , 30419 Hanover, Germany.*
Corresponding Author: S. Harb

Abstract: *The Quaternary aquifer comprises a semi-confined silt clay layer underlain by gravels, sand and clay which is extensive and highly productive aquifer through the River Nile course. The movement of groundwater is eastward from desert fringes to the River Nile.In this study measuring concentrations of radon as well as the physical properties and the chemical constitutions of ground water using GIS is used to deduce the relation between Radon and other geological, hydrological and hydro chemical parameters in 85 ground water sample of some areas in Luxor Governorate (Upper Egypt) by using the electronic radon detector RAD7, and the result showed that the concentration of radonrangedfrom 3.22±2.84to 23.30± 5.97Bq/l with average9.78± 3.63Bq/l. The Spatial distributions of* ^{222}*Rnshow a positive relation with hydro chemical properties of groundwater including pH, TDS, EC, anion and cation concentrations. And the annual effective dose for human exposure to radon ranges from12.1µSv/y to 116.5µSv/y with average48.88 µSv/y for adult, from 16.94 µSv/y to 163.1 µSv/y with average 68.44 µSv/y for children and from25.41 µSv/y to244.65µSv/y with average 102.66µSv/y for infants which are lower than the permissible limit 0.26, 0.2 and 0.1 mSv/y for Adult,Children and Infants respectively published by IAEA (IAEA 2002).*

Keyword*:Quaternary aquifer, hydro chemical parameters, Radon, RAD7, Annual effective dose.*

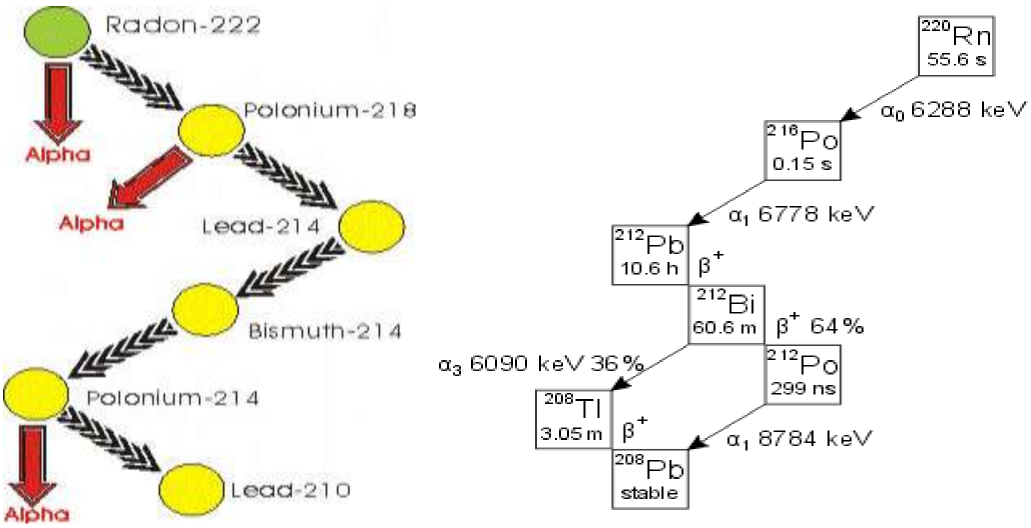
Date of Submission: 04-09-2017 Date of acceptance: 20-09-2017

I. Introduction

Radon is a naturally occurring, chemically inert, alpha particle emitting radioactive gas. This colourless, tasteless and odourless gas is produced by natural radioactive decay of uranium, radium and thorium found in trace amounts everywhere in the rocks and soils of the Earth's crust(J.M.Reid, 1986). The three naturally occurring isotopes of radon are radon (^{222}Rn) is produced from the decay of ^{238}U having natural abundance of about 99.3% of the total uranium within the Earth's crust, thoron(^{220}Rn) is produced in nature during the decay of ^{232}Th and action(^{219}Rn) is formed during the decay of ^{235}U(G. K. Gillmor, et al,2010).The most stable and abundant isotope of radon is(^{222}Rn) which has a half-life of 3.8 days(figure 1). It decays by emitting an (α) particle of (5.49 MeV) and creates radioactive daughters(J.M.Reid, 1986 and G. K. Gillmor, et al,2010).

Radon gas can also dissolve and accumulate in water from underground sources (ground water), such as wells .When water containing radon is used in the home for showering, washing dishes, and cooking, radon gas escapes from the water into the air. (This is similar to carbonated soda drinks where carbon dioxide is dissolved in the soda and is released when you open the bottle)(S.Nour, et al, 2008) .Some radon stays in the water. Radon generally isnot a concern in water that comes from lakes, rivers, and reservoirs (surface water), because the radon is released into the air before it reaches the tap(J.M.Reid, 1986 and G. K. Gillmor, et al,2010).

Radon is one of the most significant of the avoidable hazards in the environment, typically accounting for more than 50% of the dose to an average population. The U.S. EPA (2009) considers radon to be the first cause of lung cancer in America, with 15000 to 50000 people needlessly dying from the effects of radon each year. Those numbers clearly show that radon can be very dangerous for human life.



(a) (b)

Figure 1 : (a) Decay scheme of ^{222}Rn (b) Decay scheme of ^{220}Rn or Thorn

II. Geology And Geomorphology

Shuttle Radar Topography Mission (SRTM) data covering the study area were obtained as a joint project of NASA and the National Geospatial-Intelligence Agency (NGA). (SRTM) data were processed to construct a continuous DEM for the study area Figure (3 a). The DEM analysed using ARC GIS 9.3.1 software packages to visualize the landscape variations in topography. The study area is located on the alluvial plains which slope generally to the north and west and represented by the cultivated younger plain occupying the central part of the Nile Valley and older reclaimed plain at the valley fringes. The alluvial plains are surrounded by elevated structural plateaus capped by Eocene age limestone and underlain by Palaeocene age shale (Figure 2). The alluvial plains in the study area slope gently to the north and east (from about 75.5m asl about 79m asl; Figure 4). can be differentiated into a densely-cultivated younger plain occupying the central part of the Nile Valley and covered by Holocene silt and clay, and an older, reclaimed plain covered by Pleistocene sand and gravel (El-Hossary, 1994; RIGW, 1997; Figure (2).The near-surface Pliocene-Holocene sediments in the central part of the Nile Valley rest un conformably on a succession of Late Cretaceous to Early Eocene age marine sediments. The Pliocene-Holocene sediments have been subdivided into different units, each of which was deposited by an identified ancestral-modern river system, including the Eonile (Paleonile (Tplu), Protonile (Q1), Prenile (Q2), and Neonile (Q3) river systems.

In the study area, the Nile Valley broadens and the flat strips of cultivable land, extending between the river and the cliffs that bound its valley on either side, gradually increase in width northward.

The area of study is essentially occupied by sedimentary rocks belonging to the Upper Cretaceous, the Tertiary and Quaternary Said (1962, 1981 and 1991).

Pleistocene and Plio-Pleistocene sediments Terraces of the old alluvial plains are composed mainly of Prenile and Neonile sediments where gravel, sands, and shale are the dominant constituents.

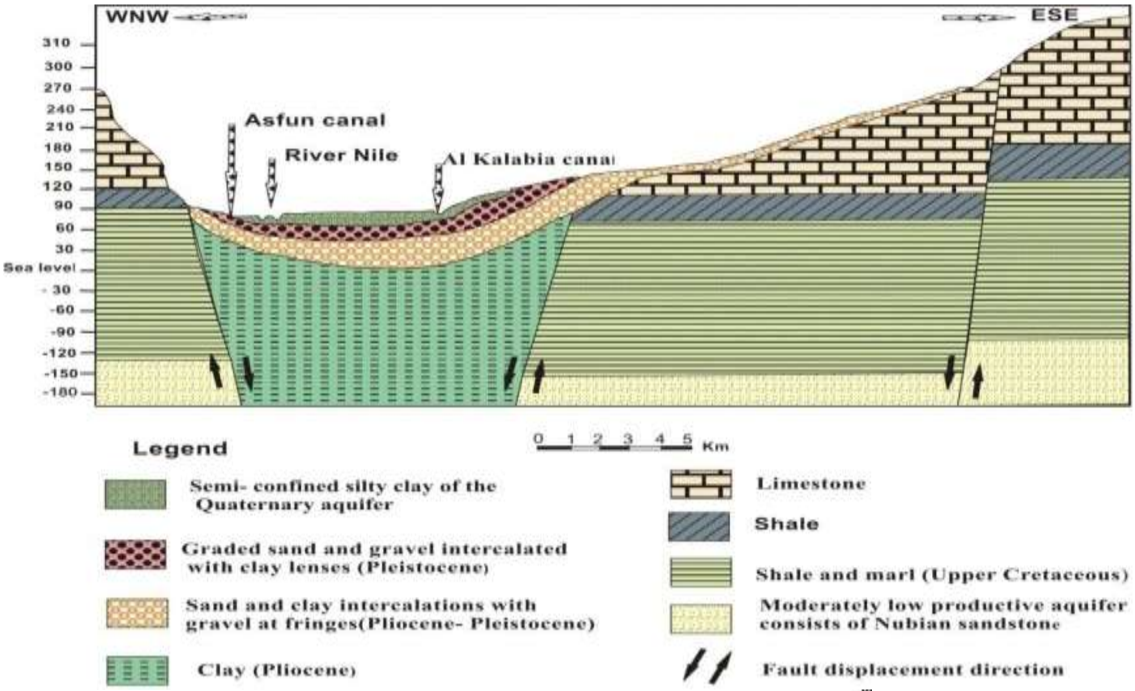
2.1. Hydrological setting

Their main groundwater aquifers in the study area, from bottom to top, are the Upper Cretaceous Nubian sandstone aquifer, Eocene fissured limestone aquifer and The Quaternary alluvial aquifer (Rigwa (1997 and 1998) and El Hosary 1994).

2.1.1. Quaternary aquifer

The Quaternary aquifer extended in the study area along the River Nile and is considered as the main aquifer. It is composed of graded sand and gravel with some intercalated clay lenses (Holocene and Pleistocene age). The thickness of the Quaternary aquifer in the study area varies from 95 m to about 5 m near the fringes of the Nile valley (Ismaeil, 2003).

An upper silty clay layer (Holocene age) with an average thickness of 13 m semi-confines the Quaternary adjacent to the River Nile, then the aquifer becomes unconfined where the capped silty clay layer is terminates near the fringes of the River Nile. Groundwater piezometric head data have been measured in the groundwater wells in Luxor area. The depths of groundwater are generally decreasing from 5 m in the west side of the study area and the lower value is around 30 m in the eastern part. Accordingly, the hydraulic heads of decrease from 97 at the desert fringes to 47 near the Nile River. This may be related to a variation of topography and/ or a local sub-basin that is structurally controlled. It decreases from desert fringes to downstream area to the Nile River reflecting the water flow direction due the NW direction (Figure 3 b).



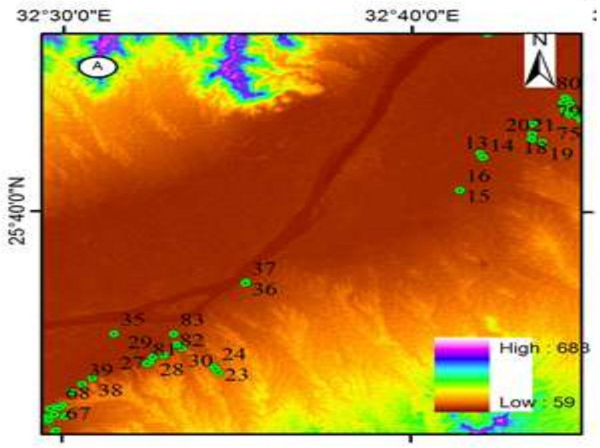


Figure 2. Hydrogeologic cross-section in Luxor study area (re-drawn after RIGW, 1997)

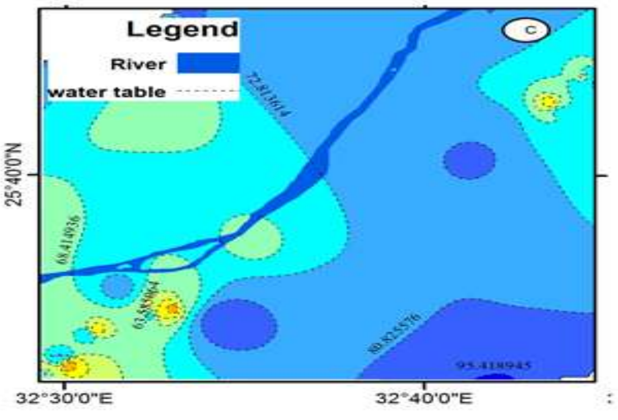


Figure 3:(a) digital elevation model using Strm(DEM)(b)Ground water table elevation and direction of groundwater movement.

III. Location Of The Study Area

Study area is located in Luxor governorate (nearly 721 km) south of the capital Cairo. Where the Luxor governorate which has an area of 3715.16) km^2 on both sides of the River Nile at Latitude (25^o 40$^-$) north, Longitude (32^o 30$^-$)east, the study area located at Latitude between (25^o 53$^-$) and (25^o 54$^-$) north, Longitude between (32^o 48$^-$) and (32^o 74$^-$) east, at the east of the River Nile, as shown in (figure 4).

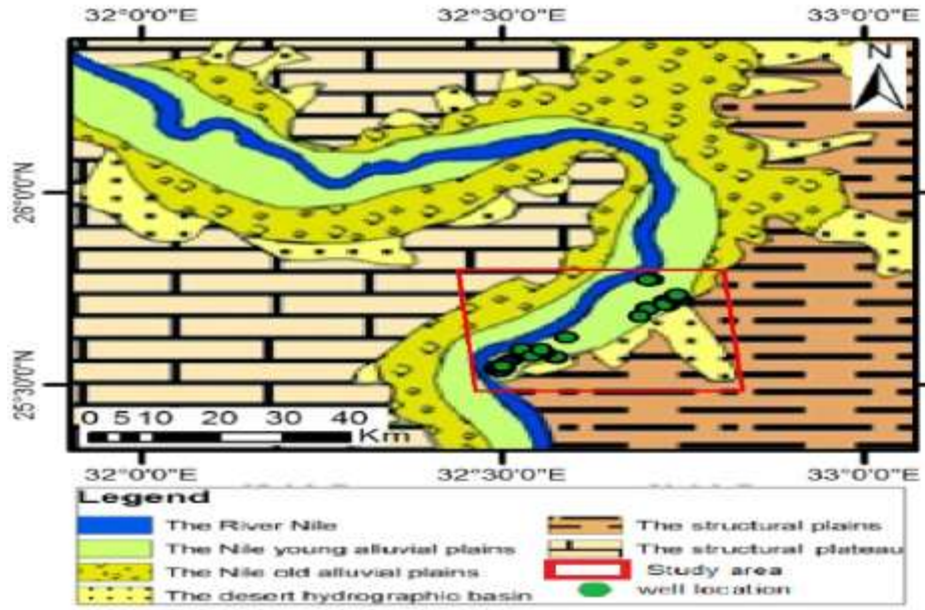


Figure 4 : Geomorphological map of the study area.

IV. Materials And Methods

4.1.Sample collection

Eighty five ground water samples from different sites in Luxor area, Egypt, have been collected in 250 ml airtight bottles. The bottles were filled completely to minimize loss of radon during sample collection.At each site the well tap was opened, and the water was allowed to run for at least 20 minutes, in order to ensure that the water came directly from the well, and was not delayed in the well pipes.During sample collectionpH, conductivity and TDS were measured. The samples were brought to the laboratory with minimum delay and were analysed at the earliest.

4.2.Activity determination:

RAD7 a radon-in-air monitor of Durridge Company of USA was used for monitoring radon concentration in 85 ground water samples collected from different locations from Luxor governorate and adjoining area using the RAD H_2O technique(Durridge Company Inc., RAD7 Radon Detector ,2011).

The RAD H_2O is an accessory to the RAD7 that measures radon in water with high accuracy, over a wide range of concentrations, capable of obtaining a reading for radon concentration in water within an hour of taking the sample(Durridge Company Inc., RAD7 RADH$_2$O Radon in Water Accessory,2011).The RAD H_2O makes use of standard, pre-set protocols, built into the RAD7, which furnish a direct reading of the radon concentration in the water sample, itself. The RAD7 detector has the capability to calculate the concentration of radon in water sample by multiplying the concentration of radon in the air loop by a fixed conversion coefficient. For a 250 mL vial of water sample conversion coefficient of 4 has been derived from the volume of the air loop, the volume of the sample and the equilibrium radon distribution coefficient at room temperature. The method makes use of a closed loop aeration design in which the air volume and water volume are kept constant and are independent of the flow rate (Durridge Company Inc.,2011).

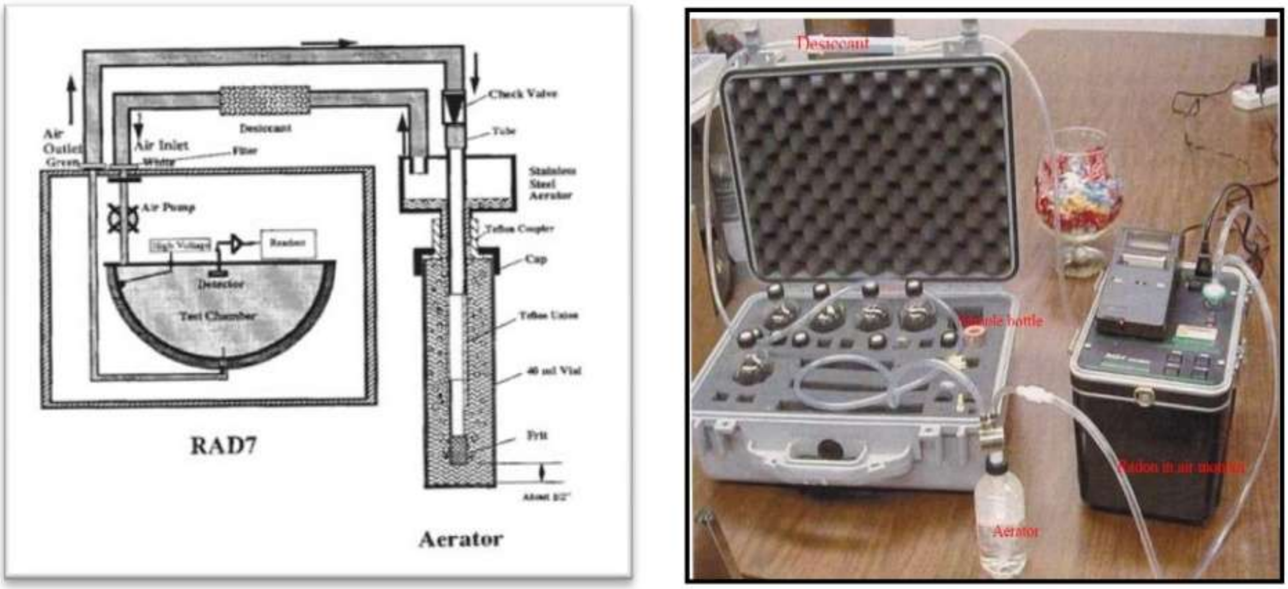
The RAD H_2O setup consists of three components, namely,(Durridge Company Inc.,2011)(a) the RAD7 radon monitor, on the left, (b)the water vial with aerator, in the case near the front, and (c) the tube of desiccant, supported by the retort standabove as shown in (Figure 5 b). Diagrammatic illustrations of the radon-monitor, RAD7with RAD H_2O accessory formeasuring radon in water samples has been shown in the(Figure 5 a) Care must be taken in taking the water samplesuch that it has never been in contact with the open air. A choice of selection among two different protocols (Wat40 and Wat 250) is available in the setup of RAD7 for a user enabling him to calculate radon concentration in vials of two different (40 or 250 mL) supplied with the equipment.

In our case we used vials of 250 mLcapacity(Durridge Company Inc., 2011).A water test in a pre-set Wat 250 protocol is normally completed in 30 min time. At the beginning of a testthe inbuilt pump of RAD7 starts running automatically for 5 min duration, aerating the sample and delivering thedegassed radon to the RAD7 measuring chamber.

During the 5 min of aeration, more than 94% of the availableradon is removed from the water. After 5 min operation the pump stops automatically and the system then waitfor a further 5 min interval. After that the system then starts counting. After 5 min, the system prints out a shortform report for a 5 min cycle(Durridge Company Inc.,2011 and N. U. Khattak ,et al, 2011).

The same thing happens again5 min afterward, and for two more 5-minperiods after that. At the end of the run (30 min after the start), the RAD7 prints out a summary, showing theaverage radon concentration in four counted cycles each of 5 min duration, a bar chart of the four readings, and accumulative spectrum.

The radon concentration shown is that of the water, and is calculated automatically by theRAD7 (Durridge Company Inc.,2011 and R. K, Somashekar, at al,2010).



(a) (b)

Figure5 : (a) Schematic diagram of RAD7, a solid state, ion implanted, planar Siliconalpha detector with RAD H2O assembly.(b) Diagram showing arrangement of apparatus for measuring radon content in water sample in a 250 mL vial

4.3. Hydrochemistry

The collected water samples were analysed for their physical and chemical constituents at the laboratories of the Geology Department and Environmental Research unit in the Faculty of Science, South Valley University.The chemical analyses were performed for the major cations (Na^+, K^+) using the Atomic Absorption Spectrophotometer Spectr-AA-55. The titration method was used for the determination of the anions CO_3^-, HCO_3^- and Cl^-. The Spectrophotometer HachDR/2400 was used for the determination of SO_4^{2-}, $PO_4^{3-}$and NO_3^-,NO_2^- in addition to some trace elements such as Fe^{2+} and Al^{+3}.

4.4. Assessment of annual effective dose :

Based on measured radionuclide concentrations in water and habitual consumption, the human health risk from irradiation due to direct ingestion can be assessed.

A method to determine the annual radiological dose for a person drinking water that contains a certain level of radioactivity was applied using the following simple equation (Kitto, 2005):

$$D = A_W \times V_W \times F \quad (2)$$

Where D the effective dose rate (mSv y^{-1}), Aw the radionuclide activity concentration in water (Bq l^{-1}), Vw the volume of water ingested annually (L) and F the effective dose equivalent conversion factor (mSvBq^{-1}).

V. Results And Discussion

5.1. Radon (Rn^{222}) Concentration

The activity concentration of ^{222}Rn determined in 85 wells in eastern band of the river in Luxor area figure 4. The concentration of ^{222}Rn varied from3.22±2.84 to 23.30± 5.97Bq/l with average 9.78± 3.63Bq/l Table 1 and figure (6 A). This narrow range for the activity concentrations is probably due to the fact that the sites studied cover an area with similar aquifer lithology and consequent not large differences in radionuclide solubility and mobility and this is probably as a result of the abundance of uranium-bearing minerals associated with phosphatic rocks commonly found in Luxor area. Similar findings have been reported by other authors (Michel, J.1991).The highest value of Rn222 was recorded in well# 74 (North east at desert fringes) whereas the lowest value recorded in well# 52 (Near Kalabia canal) this result agree with the known fact that deep groundwater with a high solid content seems to contain elevated radium activity concentration as a Consequence of the dissolution of mineral phases (Godoy,.2006) and The recharge from kalabia led to minimize the Rn-222concentration at well# 52.

Table 1: Hydrological properties associated with activity concentrations of Radon and Annual effective dose for ground water wells.

Sample No.	Latitudes	Longitudes	Ground Ele.	GW Depth	GW Ele	pH	EC (µs/cm)	T (^{O}C)	T.D.S (mg/l)	Rn-222	Annual effective dose µSv/y (Rn-222)		
											Adult	Children	Infants
1	2577452	3270515	86	9	77	7.47	777	26.6	512	8.65± 3.89	43.25	60.55	90.825
2	2577487	3270811	84	9	75	7.59	531	26.1	350	6.58± 3.08	32.9	46.06	69.09
3	2577473	3270779	80	9.5	70.5	7.68	589	25.8	388	10.25± 4.04	51.25	71.75	107.625
4	2577467	3270792	78	8	70	7.65	448	28.6	295	10.06± 4.74	50.3	70.42	105.63
5	2577253	3270332	79	9.5	69.5	7.72	517	27.8	341	5.48± 3.22	27.4	38.36	57.54
6	2577235	3270312	82	10.5	71.5	7.69	527	28.3	347	5.89± 3.12	29.45	41.23	61.845
7	2577510	3270452	95	8	87	7.64	786	26.6	518	13.19± 3.83	65.95	92.33	138.495
8	2577379	3269968	86	6.7	79.3	8.49	458	26.1	302	13.75± 3.74	68.75	96.25	144.375
9	2577378	3269939	90	8	82	7.67	557	26.1	367	16.23± 4.64	81.15	113.61	170.415
10	2577377	3269911	88	6	82	7.59	682	26.6	450	18.62± 4.91	93.1	130.34	195.51
11	2577376	3269909	95	6	89	7.53	1052	25.9	694	5.91± 3.52	29.55	41.37	62.055
12	2570159	3269952	87	12	75	7.51	3140	25.4	2072	4.53± 2.76	22.65	31.71	47.565
13	2569990	3270064	76	11	65	7.59	1345	25.7	887	8.19± 4.75	40.95	57.33	85.995
14	2569929	3270118	74	10	64	7.74	1079	26.2	712	7.11± 4.50	35.55	49.77	74.655
15	2569919	3270107	102	5	97	8.10	2400	28.1	1584	12.76± 4.41	63.8	89.32	133.98
16	2567960	3268989	103	6	97	7.9	987	29.6	651	5.24± 3.25	26.2	36.68	55.02
17	2567962	3268993	81	6	75	7.72	1939	28.8	1279	3.74± 0.95	18.7	26.18	39.27
18	2571918	3272456	78	12	66	7.81	920	28.1	607	4.44± 3.40	22.2	31.08	46.62
19	2571294	3272431	67	12	55	7.77	1475	27.9	973	6.73± 4.03	33.65	47.11	70.665
20	2570833	3272929	84	12	72	7.91	4570	27.9	3016	4.23± 2.89	21.15	29.61	44.415
21	2570988	3272415	81	15	66	7.87	1885	28.9	1244	9.21± 4.42	46.05	64.47	96.705
22	2570995	3272420	77	10	67	7.83	1637	26.8	1080	9.26± 3.82	46.3	64.82	97.23
23	2557467	3257248	114	22	92	7.81	1322	28.6	872	7.68± 3.77	38.4	53.76	80.64
24	2557119	3257490	116	22	94	8.38	1068	29.2	704	5.16± 3.29	25.8	36.12	54.18
25	2557348	3257363	107	22	85	7.85	1381	29.5	911	12.41± 5.14	62.05	86.87	130.305
26	2558145	3254877	65	17	48	7.72	318	26.7	209	9.82± 2.80	49.1	68.74	103.11
27	2557935	3254332	65	7	58	7.77	1131	26.8	746	10.49± 4.52	52.45	73.43	110.145
28	2557742	3254230	78	19	59	7.74	1770	26.9	1168	7.65± 4.44	38.25	53.55	80.325
29	2558038	3254374	68	5	63	7.76	1777	27.1	1172	4.25± 3.79	21.25	29.75	44.625
30	2558039	3254374	90	20	70	7.85	2106	25.9	1389	11.75± 4.46	58.75	82.25	123.375
31	2558555	3255754	90	22	68	7.83	2108	26.3	1391	11.29± 5.31	56.45	79.03	118.545
32	2558743	3255538	84	14	70	7.85	1625	26.4	1072	9.12± 3.16	45.6	63.84	95.76
33	2558767	3255497	84	14	70	7.89	1778	26.5	1173	21.57± 6.10	107.85	150.99	226.485
34	2558773	3255502	83	22	61	7.83	541	24.1	357	10.18± 3.45	50.9	71.26	106.89
35	2554132	3249193	117	25	92	7.86	944	25	623	8.47± 2.81	42.35	59.29	88.935
36	2559401	3252516	95	12	83	7.79	583	24.3	384	12.83± 4.92	64.15	89.81	134.715
37	2562506	3258797	87	9	78	7.83	602	24.1	397	9.18± 3.07	45.9	64.26	96.39
38	2562431	3258763	61	6	55	7.83	2300	23.7	1518	10.56± 3.54	52.8	73.92	110.88
39	2556784	3251466	65	6	59	7.51	1464	23.5	966	17.68± 4.11	88.4	123.76	185.64
40	2556397	3250999	79	4	75	7.61	1572	22.8	1037	18.23± 3.88	91.15	127.61	191.415
41	2555960	3250468	81	7	74	7.53	1992	23	1314	20.30± 4.90	101.5	142.1	213.15
42	2555959	3250466	66	4	62	7.25	1721	24.9	1135	5.48± 2.48	27.4	38.36	57.54
43	2554231	3248937	67	3	64	7.37	2680	24.8	1768	14.32± 3.67	71.6	100.24	150.36
44	2554290	3248978	70	3	67	7.33	2270	24.6	1498	7.80± 2.80	39	54.6	81.9
45	2554334	3249110	74	8	66	7.13	4440	24.5	2930	9.71± 3.14	48.55	67.97	101.955
46	2554330	3249126	62	15	47	7.63	639	24.7	421	8.38± 2.98	41.9	58.66	87.99
47	2554148	3249174	81	15	66	7.52	906	24.5	598	3.92± 2.58	19.6	27.44	41.16
48	2554213	3249217	82	15	67	7.33	723	24.6	477	3.31± 2.45	16.55	23.17	34.755
49	2554300	3249126	76	4	72	7.33	1807	24.7	1192	5.79± 3.02	28.95	40.53	60.795
50	2554301	3249127	63	9	44	7.26	1818	25.2	1200	10.61± 3.22	53.05	74.27	111.405
51	2554237	3249302	84	9	75	7.33	1950	25.3	1287	5.84± 2.59	29.2	40.88	61.32
52	2554194	3249345	91	20	71	7.42	800	25.3	528	3.22± 2.84	16.1	22.54	33.81
53	2554187	3249408	92	30	62	7.47	666	25.5	439	10.17± 3.33	50.85	71.19	106.785
54	2554465	3249344	84	10	74	7.45	1704	25.2	1124	5.66± 2.58	28.3	39.62	59.43
55	2554463	3249367	84	10	74	7.93	1671	24.8	1103	3.77± 2.2	18.85	26.39	39.585
56	2554389	3249435	83	12	71	7.82	803	24.1	530	7.16± 2.74	35.8	50.12	75.18
57	2554286	3249420	90	20	70	7.27	593	23.9	391	15.16± 4.27	75.8	106.12	159.18
58	2554287	3249420	67	19	18	7.48	963	25.3	635	13.27± 3.45	66.35	92.89	139.335
59	2553613	3249647	89	16	73	7.47	997	25.4	658	14.22± 4.14	71.1	99.54	149.31
60	2553506	3249683	90	15	75	7.14	684	25	451	10.97± 3.79	54.85	76.79	115.185

61	2553675	3249727	90	14	76	7.37	887	24.5	585	7.70± 3.30	38.5	53.9	80.85
62	2553674	3249750	73	23	50	7.54	747	24.6	493	11.99± 3.37	59.95	83.93	125.895
63	2554962	3249456	89	7	82	7.51	1221	24.4	805	13.56± 3.57	67.8	94.92	142.38
64	2554596	3249677	91	12	79	7.65	889	23.8	586	7.24± 3.30	36.2	50.68	76.02
65	2554498	3250185	93	12	81	7.51	326	24.2	215	3.42± 2.28	12.1	16.94	25.41
66	2554500	3250187	59	22	10	7.61	1275	24.5	841	9.27± 3.03	46.35	64.89	97.335
67	2555155	3250071	95	19	76	7.66	837	21.8	552	11.06± 3.80	55.3	77.42	116.13
68	2555046	3249766	87	12	75	7.76	1067	21.9	704	15.62± 3.77	78.1	109.34	164.01
69	2555028	3249920	90	10	80	7.47	1619	21.5	1068	14.42± 4.27	72.1	100.94	151.41
70	2555028	3249920	67	13	54	7.42	4150	21.1	2739	4.69± 2.73	23.45	32.83	49.245
71	2572729	3273986	82	12	70	7.40	3490	21.3	2303	7.10± 3.20	35.5	49.7	74.55
72	2572435	3274252	87	13	74	7.17	7900	21.6	5214	4.19± 2.69	20.95	29.33	43.995
73	2573167	3273917	80	7	73	7.25	4310	21.9	2844	7.43± 3.28	37.15	52.01	78.015
74	2573379	3274138	81	10	71	7.39	3760	21.9	2481	23.30± 5.97	116.5	163.1	244.65
75	2572588	3274490	88	12	76	7.16	6850	22.7	4521	15.92± 3.77	79.6	111.44	167.16
76	2572455	3274478	87	15	72	7.05	7150	22.3	4719	13.05± 3.57	65.25	91.35	137.025
77	2572149	3274776	91	17	74	7.23	4000	22.8	2640	15.02± 3.74	75.1	105.14	157.71
78	2573007	3274139	65	14	42	7.48	5090	23.6	3359	4.53± 2.46	22.65	31.71	47.565
79	2573088	3274274	84	9	75	7.55	6690	23.7	4415	6.66± 2.70	33.3	46.62	69.93
80	2573077	3274240	85	10	75	7.52	6580	22.9	4343	11.96± 3.95	59.8	83.72	125.58
81	2573464	3274003	85	10	75	7.58	2320	23.9	1531	10.99± 3.72	54.95	76.93	115.395
82	2573464	3274003	59	11	48	7.52	1656	26	1093	10.63± 3.79	53.15	74.41	111.615
83	2557631	3254071	93	17	76	7.74	1151	26.1	759	8.55± 4.47	42.75	59.85	89.775
84	2559386	3255350	77	13	64	7.73	1565	26.1	1033	13.94± 5.46	69.7	97.58	146.37
85	2559389	3255358	82	14	68	7.70	1010	26	666	12.39± 4.95	61.95	86.73	130.095
MIN			59	5	47	7.05	318	21.1	209	3.22±2.84	12.1	16.94	25.41
MAX			117	30	97	8.49	7900	29.6	5214	23.30± 5.97	116.5	163.1	244.65
Average			83.54	12.51	71	7.61	1871.2	25.24	1234.66	9.78± 3.63	48.88	68.44	102.66

5.2. Hydrochemistry:

The pH level in the groundwater samples table (2) varied from 7.05 to 8.49 indicating slightly alkaline conditions. The TDS depending on the solubility of rocks and soils contact in water of collected groundwater varies in the Quaternary aquifer at the study area from 209 mg/l to 5214 mg/l with an average 1234.66 mg/l. The maximum value (5214 mg/l) noticed in the well # 72 (north east of the study area) and minimum in well # 26(near kalabia canal) reflecting very high saline characters. These very high values might be due to the character of the alluvial deposits, which are rich in soluble minerals.

Leaching and dissolution processes of the surrounding carbonates, shale, marl and Pliocene marine deposits in addition to agricultural return flow under the high evaporation rate Higher TDS(Table 1) and(figure 6b)Was observed in the southwestward to the downstream area. Movement of groundwater supports the potential of leaching processes of natural salts in the soil and sediments a resulting the traditional flood irrigation, so modern methods of irrigation are recommended particularly at the new reclaimed land in the desert fringes. The Quaternary aquifer is recharged from canals and drains that maybe minimize the high salinity as inferred from well #26 near the kalabia canal. This supports bicarbonate dissolving processes westward nears the limestone plateaus. Water hardness is easily noticed in laundry applications in the form of greatly reducing the effectiveness of soaps and detergents. It can also cause pipe rusting in water heating and cooling systems. According to the hardness a value, ground water in the study area is classified as very hard water (> 300 mg/l; Sawyer and McCarty 1967) the total hardness ranges from 159.74 to 1790.88 with an average of 460.85 mg/lfigure(8) and Table2.(Sodium is the dominant cation in the chemical faces of most groundwater samplesranging from 2.89 to 679.58 with average 261.21 mg/l,(figure(7) and Table 2, followed by Mg ,Ca, K ,Al where chloride is the dominant anion followed by bicarbonateand sulphate. Phosphate anion ranges from 0.22 (in well # 56)to 1.54 mg/l(in well #74)figure(8) and Table 2.

Table 2: Hydro chemical properties for ground water wells

S.No.	TOTAL Hardness (mg/l)	ALK. (mg/l)	Cl^- (l/gm)	NO_3 (l/gm)	NO_2 (mg/l)	SO_4 (mg/l)	Po_4 (mg/l)	Fe^{2+} (mg/l)	AL^{3+} (µg/l)	Na^+ (mg/l)	K^+ (mg/l)
1	338.21	491.82	21.13	0.503	0.006	24.06	0.45	0.024	81.77	37.56	14.76
2	189.28	282.66	16.76	0.38	0.006	14.15	0.68	0.020	124.63	203.94	10.48
3	231.3	340.62	17.14	0.32	0.008	21.98	0.59	0.033	40.04	176.21	7.27
4	175.14	266.28	18.47	0.25	0.006	34.32	0.73	0.025	149.28	127.68	5.13
5	183.87	308.28	16.56	0.28	0.006	15.90	0.57	0.023	156.87	44.48	11.55
6	193.02	321.72	18.85	0.53	0.012	18.85	0.82	0.029	129.56	58.35	6.20
7	281.22	481.74	19.61	0.87	0.035	45.44	0.67	0.141	77.97	133.60	8.34
8	183.87	263.76	21.52	0.53	0.006	16.41	0.77	0.035	132.21	113.81	11.55
9	197.6	319.2	20.56	1.57	0.010	17.80	0.87	0.036	84.80	2.89	13.69
10	435.14	471.24	31.22	1.41	0.006	91.67	0.89	0.027	152.32	37.55	14.76

11	412.67	436.38	67.97	0.093	0.014	124.35	0.58	0.021	58.63	93.02	12.62
12	904.38	734.58	347.1	11.53	0.006	389.41	0.75	0.019	51.04	86.08	10.48
13	500.86	593.88	67.02	10.53	0.029	131.13	1.09	0.021	52.56	30.62	9.41
14	562.02	521.22	39.98	10.62	0.077	73.25	0.79	0.080	66.21	162.35	11.55
15	368.99	965.16	175.36	7.22	0.046	234.54	0.84	0.106	71.52	391.13	15.83
16	314.1	419.58	61.88	6.77	0.012	49.26	0.65	0.019	65.07	231.68	9.41
17	591.14	619.5	173.26	7.25	0.023	288.60	1.04	0.020	68.11	384.20	9.42
18	423.49	300.3	76.92	1.09	0.006	127.83	1.22	0.018	98.08	51.42	7.27
19	562.43	412.44	135.37	8.42	0.054	246.54	0.56	0.016	59.39	2.89	11.56
20	971.78	466.62	825.57	11.59	0.29	403.14	0.58	0.018	51.04	488.20	20.11
21	422.66	469.56	200.68	6.98	0.081	297.81	1.02	0.029	59.00	370.34	11.55
22	500.45	235.62	278.94	4.67	0.24	266.87	0.89	0.015	71.90	280.21	10.48
23	311.58	241.08	165.65	2.30	0.04	147.29	0.62	0.039	63.56	245.54	12.62
24	263.74	174.72	216.48	1.70	0.027	148.16	0.39	0.029	60.15	314.87	10.48
25	308.67	179.76	231.34	2.34	0.077	201.87	1.16	0.020	65.47	301.01	9.42
26	215.90	175.56	41.7	0.44	0.008	12.59	0.86	0.029	52.56	113.82	4.07
27	208	273.42	119.38	5.21	0.043	172.50	0.38	0.025	68.87	55.61	9.42
28	316.16	298.62	214.96	11.64	0.086	266.87	0.64	0.039	69.25	280.21	11.56
29	284.13	330.96	107.96	3.33	0.042	51.52	0.55	0.034	49.52	238.61	8.35
30	294.94	351.12	201.06	11.74	0.096	308.07	0.66	0.029	58.25	72.22	7.28
31	335.71	297.78	250.38	11.83	0.065	315.37	0.77	0.029	64.70	529.80	10.48
32	312.42	263.76	184.50	11.88	0.019	223.77	0.97	0.029	71.14	398.07	23.32
33	280.38	321.72	195.73	11.98	0.016	216.99	1.26	0.025	77.97	398.07	14.76
34	199.68	302.40	28.56	0.45	0.006	29.62	0.99	0.057	65.83	273.27	11.55
35	300.35	283.08	53.31	1.56	0.006	132.17	1.11	0.043	105.66	245.54	10.48
36	285.79	311.64	19.23	0.35	0.411	14.33	0.53	0.052	90.87	185.60	7.27
37	230.88	278.04	19.61	4.96	0.040	31.36	0.73	0.020	93.90	93.02	12.62
38	634.82	493.08	179.55	12.36	0.012	300.59	0.96	0.015	48.39	398.07	27.60
39	458.85	560.28	96.91	11.94	0.006	168.15	1.15	0.025	85.94	287.14	35.09
40	462.18	425.04	76.16	11.79	0.010	212.47	0.78	0.025	90.49	328.74	14.76
41	334.88	687.12	60.74	11.63	0.044	247.93	1.25	0.015	96.18	502.06	8.34
42	378.14	524.58	137.47	11.60	0.048	200.30	1.14	0.015	93.52	377.27	15.83
43	499.2	665.28	208.68	11.71	0.149	323.88	0.57	0.011	79.87	356.47	8.34
44	398.53	660.66	155.37	11.89	0.019	286.86	0.73	0.011	57.49	273.27	9.41
45	993.82	460.74	768.64	12.32	0.039	366.47	0.64	0.015	52.94	425.80	19.04
46	297.44	283.92	50.27	4.90	0.017	363.86	1.15	0.015	62.42	44.48	11.55
47	311.17	278.04	65.88	11.76	0.019	17.11	0.81	0.020	47.63	169.28	13.69
48	272.06	256.2	134.99	10.23	0.044	39.88	0.85	0.015	45.35	211.60	12.62
49	587.39	359.52	216.29	12.09	0.037	131.82	0.74	0.015	47.63	314.87	16.90
50	532.48	409.08	188.12	12.00	0.041	141.56	0.66	0.011	52.56	328.74	19.04
51	524.16	250.74	274.94	12.02	0.060	254.36	0.94	0.029	59.77	356.47	22.25
52	314.91	232.68	93.3	5.85	0.027	53.61	0.46	0.029	69.63	44.48	9.41
53	297.44	215.88	67.40	4.34	0.033	43.70	0.44	0.029	51.80	16.75	6.20
54	182.21	498.96	137.1	11.74	0.136	180.32	0.57	0.034	54.84	467.40	21.18
55	284.54	444.36	155.56	10.81	0.023	220.12	0.87	0.025	50.66	280.21	19.04
56	266.66	264.18	64.93	7.00	0.035	60.21	0.22	0.020	43.08	210.88	10.48
57	229.63	99.54	106.43	3.27	0.021	29.28	1.19	0.09	60.52	37.55	8.34
58	463.01	364.56	94.44	9.18	0.046	10.68	0.58	0.015	70.77	133.60	5.13
59	343.62	149.94	140.52	8.91	0.166	101.58	0.95	0.020	85.18	169.28	7.27
60	284.13	275.94	38.84	6.76	0.319	45.44	1.01	0.020	52.56	155.41	4.06
61	347.78	264.18	61.69	8.54	0.111	113.05	1.03	0.016	65.46	134.61	6.20
62	267.49	235.62	86.25	2.51	0.037	52.91	0.76	0.015	46.87	86.08	8.34
63	255.01	427.98	79.02	7.60	0.094	137.56	1.06	0.014	71.90	176.21	5.13
64	283.71	244.44	75.02	0.487	0.128	106.1	1.37	0.012	63.18	155.41	10.48
65	159.74	142.38	21.32	8.91	0.027	25.28	1.27	0.018	58.63	169.28	7.27
66	364	280.56	97.29	5.26	0.014	248.97	0.79	0.018	70.01	266.34	8.34
67	284.96	342.3	59.02	0.717	0.029	50.83	1.18	0.020	66.21	79.15	13.69
68	246.27	361.2	77.68	2.73	0.017	89.24	0.92	0.001	60.90	190.08	11.55
69	607.36	286.44	248.09	8.65	0.023	179.62	1.21	0.014	61.28	20.94	16.90
70	939.33	345.24	615.37	5.53	0.019	418.78	1.34	0.014	48.77	618.91	20.12
71	868.61	268.80	521.12	3.49	0.614	387.15	1.17	0.017	39.66	246.26	20.11
72	1790.88	212.94	1541.29	11.99	0.128	449.55	0.44	0.014	34.73	488.92	30.82
73	1027.94	458.64	549.88	8.30	0.209	416.70	1.03	0.019	20.70	610.25	16.90
74	926.02	501.48	417.55	11.22	0.023	404.18	1.54	0.012	19.56	592.91	17.97
75	1251.33	217.56	1223.70	12.06	2.32	427.30	1.14	0.017	18.42	670.91	25.46
76	1364.48	250.32	1240.65	12.00	0.203	441.03	1.27	0.019	16.15	679.58	14.76
77	756.70	199.08	662.59	11.76	0.281	395.15	1.35	0.017	13.87	515.93	17.97
78	944.32	388.5	656.50	0.37	0.079	430.78	1.43	0.021	43.84	653.58	27.60
79	1404.42	372.96	1078.99	4.82	0.103	451.46	1.22	0.072	4.01	610.25	26.53
80	958.88	376.32	1014.83	1.70	1.38	453.03	0.77	0.038	5.53	636.25	11.55

81	**536.64**	**488.46**	**189.45**	**11.72**	**1.20**	**348.74**	**1.25**	**0.031**	**4.01**	**358.93**	**14.76**
82	**428.06**	**421.68**	**148.89**	**11.78**	**0.037**	**154.59**	**0.35**	**0.014**	**12.73**	**273.27**	**22.25**
83	**297.86**	**263.34**	**96.72**	**11.72**	**0.060**	**196.13**	**1.01**	**0.017**	**7.42**	**332.93**	**10.48**
84	**188.03**	**531.72**	**86.63**	**11.74**	**0.052**	**221.68**	**1.29**	**0.014**	**26.39**	**332.93**	**10.48**
85	**229.63**	**336.84**	**69.88**	**11.77**	**0.065**	**76.38**	**0.91**	**0.016**	**7.42**	**159.60**	**13.69**
MIN	**159.74**	**99.54**	**16.56**	**0.093**	**0.006**	**10.68**	**0.22**	**0.001**	**4.01**	**2.89**	**4.06**
MAX	**1790.88**	**965.16**	**1541.29**	**12.36**	**2.32**	**453.03**	**1.54**	**0.141**	**156.87**	**679.58**	**35.09**
Avrage	**460.85**	**363.35**	**225.1**	**6.92**	**0.125**	**184.5**	**0.86**	**0.027**	**62.43**	**261.21**	**13.20**

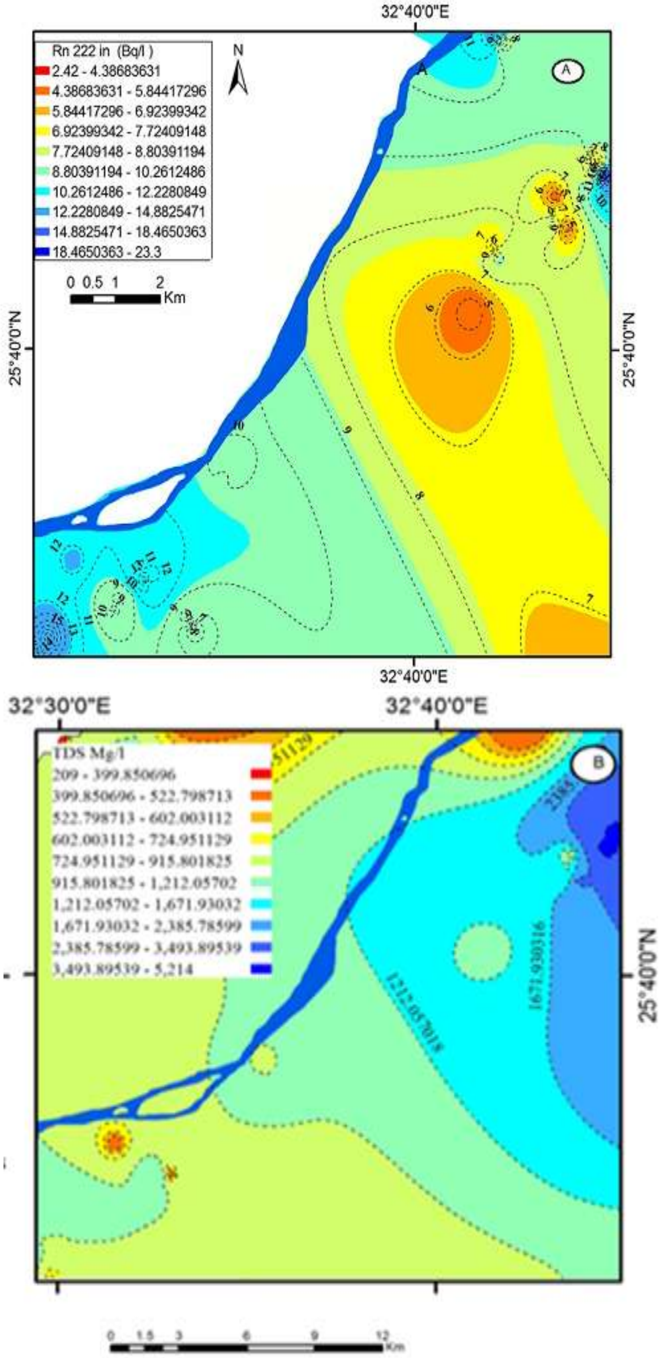


Figure 6: (A) Spatial distribution of Radon-222 concentration (Bq/l)(b) Spatial distribution of TDS concentration (mg/l)

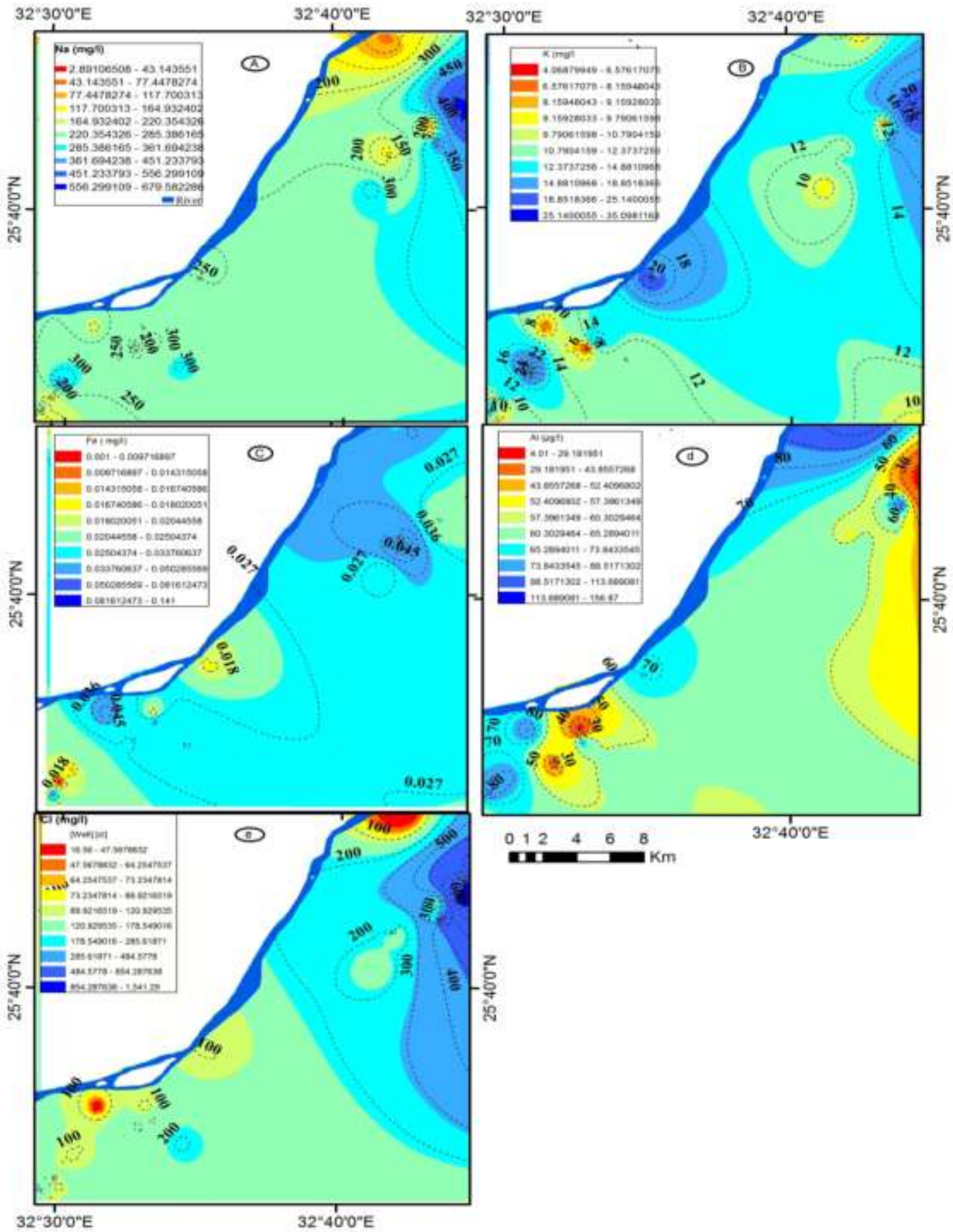


Figure 7: Spatial distribution of hydro chemical analysis concentration (mg/l)
(a) Na^{+} (b) K^{+} (c) Fe^{2+} (d) AL^{3+} (µg/l) (e) CL^{-}

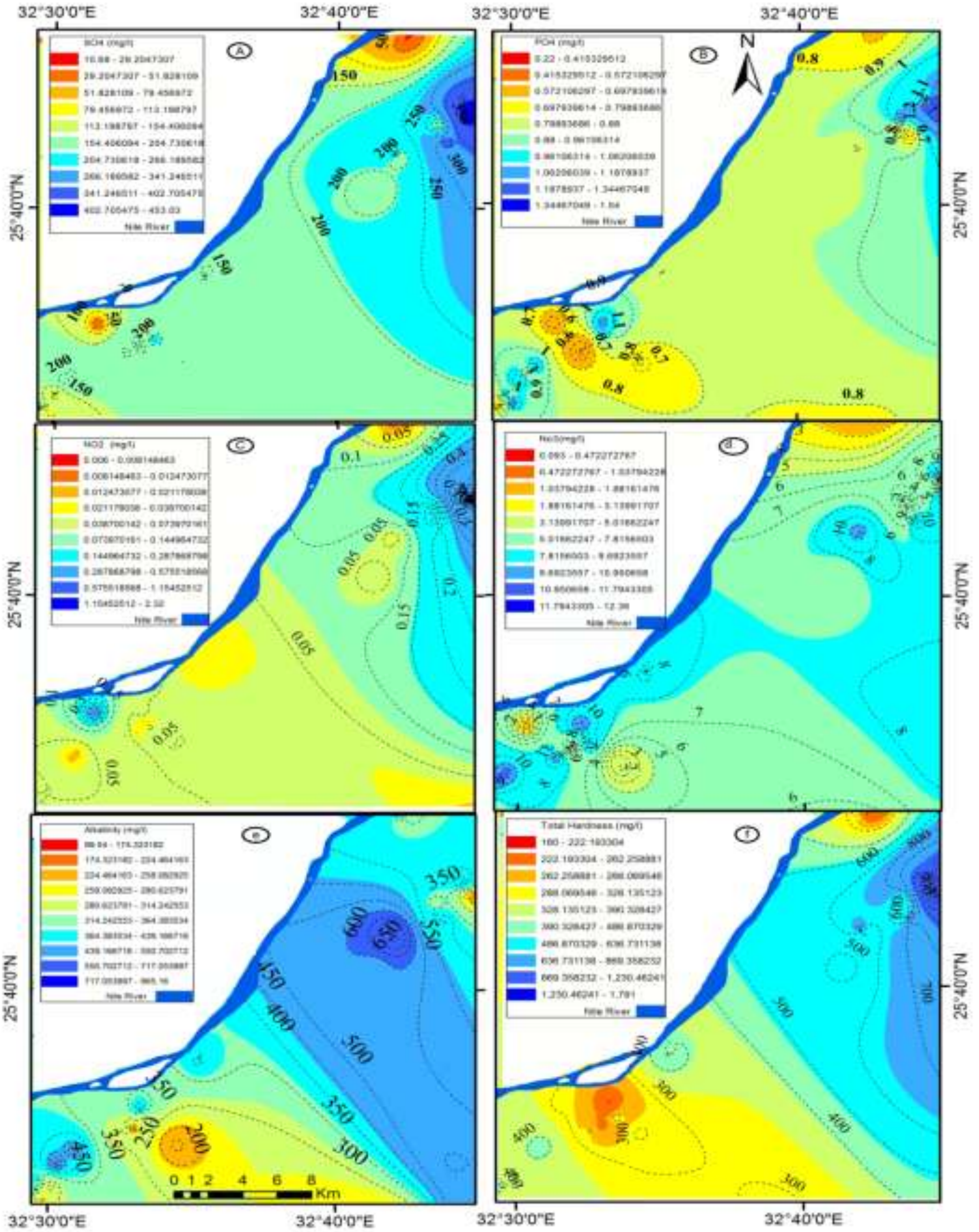


Figure 8: Spatial distribution of hydro chemical analysis concentration (mg/l)
(a): SO_4^{-2} (b): PO_4^{-3} (c) : NO_2^- (d) : NO_3^- (e) : Alkalinity (f): Total Hardness

5.3. The annual effective dose :

The effective dose due to intake of ^{222}Rn was assessed usingthe measured activity of ^{222}Rn and dose per unit activity ofradon ingested as shown in Table 1. The range of effectivedose is ranges from 12.1 µSv/y to 116.5 µSv/y with average 48.88 µSv/y for adult , from 16.94 µSv/y to 163.1 µSv/y with average 68.44 µSv/y for children and from 25.41 µSv/y to244.65µSv/y with average 102.66 µSv/y for infantswhich are lower thanwhen compared with the average value of 2.4 mSv/y for normal the expermissible limit 0.26, 0.2 and 0.1 mSv/y for Adult ,Children and Infants respectively published by IAEA (IAEA 2002).

Table 3: The activity concentration of Rn^{222} in Bq /l of water samples in the present investigation in comparison with other countries.

Country	Type of water	Rn^{222}(Bq/l)	Reference
Luxor –Egypt	Groundwater	3.22 ±2.84–23.30±5.97 (Mean 9.78 ±3.63)	present study
Iraq- Nenava	Natural water	1.133	Sabah,2004
Iraq-River Hilla	Natural water	0.103	Khalid H.H Al-Attiyah et al,2013
Turkey		0.091	C. Canbazoğlu, et al,2012
Kuwait		0.74	A. F. Maged,2009
Syria		13	G. Jonsson,1991
Iran	Hot spring	(0.21- 3.89)	A.Behtash, et al,2012
Jordon	Natural water ,Hot spring	3.9	A.T .Al-Kazwini,et al, 2003
Khartoum	Groundwater	59.2	A. K. Sam,et al.2011
Algeria	Mineral water	7	D. Amrani,2002
India	Groundwater	0.0665 – 0.0203	R.Mehra, et al,2010 .

VI. Summary And Conclusion

Based on the hydrological parameter the major groundwater movement direction is westward depending in hydraulic head variation and topography of the area. The activity concentration of Rn^{222} decrease with the same direction of groundwater movement direction whereas, the maximum concentrations are found in the west ate the desert fringes and the minimum concentrations are found in the east of the study area.

The study of radon in groundwater showed all samples tested had radon activity concentrations well ranged from (3.22±2.84to 23.30± 5.97Bq/l with average 9.78± 3.63Bq/l) show that about 49 sample from the 85studied sample(about 58 %) is higher than the recommended EC(European Commission Recommendation ,2001) action level of 1 MBq. M^{-3} the related by organizations as themaximum allowableconcentration of radon in water (11 $Bq.L^{-1}$) (As defined by the Environmental Protection Agency EPA 2009).

The calculated effective dose for different age groups, ranged from 12.1 µSv/y to 116.5 µSv/y with average 48.88 µSv/y for adult , from 16.94 µSv/y to 163.1 µSv/y with average 68.44 µSv/y for children and from 25.41 µSv/y to 244.65 µSv/y with average 102.66 µSv/y for infants which are lower than when compared with the average value of 2.4 mSv/y for normal theexpermissible limit 0.26, 0.2 and 0.1 mSv/y for Adult,Children and Infants respectively published by IAEA (IAEA 2002).

References

[1] J.M.Reid,The Atomic Nucleus, (Manchester University Press), second edition,1986.

[2] G. K. Gilmore and N. Jabarivasal," A reconnaissance study of radon concentrations in Hamadan City, Iran", Natural Hazards and Earth System Sciences,Vol. 10, p.857–863, 2010.

[3] S.Nour, H.Kurosaki, K.Inn, J.LaRosa,L.Lucas, P.Volkovitsky, and OutolaK.Koepenick,Investigation of radioactivity in selected drinking water samples from Maryland, Journal ofRadio analytical and Nuclear Chemistry, Vol. 277, No.1, p. 155-159, 2008.

[4] Environmental Protection Agency United States Environmental Protection Agency, A citizen'sguide to radon.,2009.

[5] RIGW (1998): Well hydrology and database,Hydrological maps of Egypt, Scale 1:100,000. WaterResearch Center, Ministry of Public Works and Water Resources, Egypt.

[6] RIGW, (1997): Detailed hydrogeological maps of Luxor and Esna areas (1:100.000). Research Institute for Groundwater, Ministry of public works and water resources, Cairo, Egypt.

[7] El Hossary, M. M. (1994): Hydrogeological and hydrochemicalstudies on Luxor area, Southern Egypt. MSc. Thesis, Ain Shams University, Cairo, Egypt,p121.

[8] Said, R. (1962): The Geology of Egypt. El Sevier. Amsterdam, New York. Said, R. 1981.The Geological evaluation of the River Nile.Springier-Verlage.Publi., New York. Ink.P. 151.

[9] Said, R. (1981): The geological evaluation of the River Nile.Springier-Verlage.Publi., New York. Ink.P. 151.

[10] Said, R. (1991): Quaternary in Said. Geology of Egypt. A. A. Balkema/ Rotterdam / Brookfield, pp. 487-511.

[11] Ismail, A. (2003): Geophysical, hydrological and archaeological investigation in the east bank area of Luxor–Southern Egypt: Ph.D. Thesis, University of Missouri-Rolla, Rolla, Missouri, USA, 211p.

[12] Durridge Company Inc., RAD7 Radon Detector. User Manual, 2011.

[13] Durridge Company Inc., RAD7 RADH2O Radon in Water Accessory. Owner's Manual, 2011.

[14] Durridge Company Inc., Manual CAPTURE version 4.7.5 ,2011.

[15] N. U. Khattak , M. A. Khan, M. T. Shah and M. W. Javed, Radon concentration in drinking watersources of the Main Campus of the University of Peshawar and surrounding areas, KhyberPakhtunkhwa, Pakistan, Journal of Radioanalytical and Nuclear Chemistry, Vol.290, p.493-505,2011.

[16] R. K, Somashekar and P. Ravikumar, Radon concentration in groundwater of Varahi andMarkandeya river basins, Karnataka State, India, Journal of Radioanalytical and Nuclear Chemistry,Vol. 285, p.343-351, 2010.

[17] Kitto, M. E. and Sook Kim, M. Naturally occurring radionuclides in Community water supplies of New York State. Health Phys. 88(3), 253–260 (2005).

[18] Michel: Michel, J. Relationship of radium and radon with geological formations. In: Radon, Radium and Uranium in Drinking Water. Richard Corthern, C. and Rebers, P. A. (Eds). Secondedn. (USA: Lewis Publishers) pp. 83–96 (1991).

[19] Godoy, J. M. and Godoy, M. L. Natural radioactivity in Brazilian groundwater. J. Environ. Radioactiv.85(1) 71–83 (2006).

[20] Sawyer. C. N. and McCarty, P. L. (1967). Chemistry for sanitary engineers, 2nd ed. McGraw – Hill, New York, 518 pp.

[21] IAEA: International Agency Energy Agency. Specification of radionuclide content in Commodities requiring regulation for purposes of Radiation Protection.Safety Guide (draft), (Vienna: IAEA) (2002).
[22] Sabah Yousif Hassan Ukla, Determination of Radon, Uranium and Other Radioactive IsotopesConcentration In Different Types of Natural Water In Nenava Governorate, M .Sc., University ofMosul,2004.
[23] C. Canbazoğlu, M. Doğru, N. çelebi and G. Kopuz, Assessment of natural radioactivity inElazıg region eastern Turkey, Journal of Radioanalytical and Nuclear Chemistry, Vol.292, p. 375-380, 2012 .F. Maged, Estimating the radon concentration in water and indoor air, Environ MonitAssess, Vol.152, p.195–201, 2009.
[24] G. Jonsson, Solid State Nuclear Track Detector in Radon Measurement Indoor and Soil, Nucl.Tracks Radiat. Meas., Vol. 25, P.335-338, 1991.
[25] A.Behtash, A. Jalili-Majareshin and D.Rezaei-Ochbelagh, Radon concentration in hot springsof the touristic city of Sarein and methods to reduce radon in water, Radiation Physics and Chemistry, Vol.81, p. 749–757,2012.
[26] A.T. Al-Kazwini and M.A. Hasan, Radon Concentration in Jordanian Drinking Water and HotSprings. Institute of Physics Publishing, J. Radiol. Port. 23, p. 439-448, 2003.K. Sam , H. Idriss and I. Salih, Study of radon in ground water and physicochemicalparameters in Khartoum state, Journal of Radioanalytical and Nuclear Chemistry, Vol.290, p.333-338, 2011.
[27] D. Amrani, Natural radioactivity in Algerian bottled mineral waters, Journal of Radioanalyticaland Nuclear Chemistry, Vol. 252, No. 3 , P.597–600, 2002.
[28] EC (European Commission Recommendation) On the protection of the public against exposureto radon in drinking water supplies, Official Journal of the European Communities, L344,85–88,2001.

S. Harb. "Impact of Geological and Hydrological Setting on Radon-222 Concentration of Groundwater from Luxor, Egypt." IOSR Journal of Applied Physics (IOSR-JAP), vol. 9, no. 5, 2017, pp. 34–46.