Summary and conclusions

This thesis deals with study of the suitability of site for the construction the nuclear power plant. This facilitates comparative study between the results obtained from this work and those, which might occur after the construction of the plant. To assess this purpose and to study the impact of power plant on the surrounding area, the study of environmental radioactivity in different environmental compartments and study hydrochemistry and isotope hydrology of water resources in area under investigation took place. The thesis is subdivided into two parts; the first one deals with study of the radioactivity in the environment and the other part is studied hydrochemistry and isotope hydrology of water resources. Each part is subdivided into three main chapters including the introduction, the experimental, and the results and discussions.

For the first part, it is intended to in chapter-I, the introduction, deals with presence of radionuclides in different environmental compartments and the potential pathways to the man. In this chapter, also, discuss the steps for selection El Dabaa site and the factor which controlled for site selection. Also deals with the literature review of similar work on environmental radioactivity.

Chapter two contains the experimental part. In this chapter, the methods of samples collection were described for collected water samples, biological samples, soil and sediment samples. In this chapter, the description of used instrument for nuclear spectroscopic techniques was depicted. This instrument includes a hyper pure germanium detector. The instrument is calibrated and used for radioactivity measurements. The adjustment of this instrument was elaborated through energy calibration, efficiency determination and background subtraction.

Chapter three includes, the results and discussions. This chapter deals with environmental surveillance for a nuclear measuring program for determination of naturally occurring radioactive elements in different environmental samples to assess highly qualified non destructive and quantitative determinations. In this chapter, the radioactivity levels of main naturally occurring radionuclides of potassium-40, uranium-238(radium-226), and thorium-232 were determined in environmental samples together with caesium-137 if present. The analysis of samples includes several soil, sediment, water and biological samples. In case of soil and sediments giving the following radioactivity:

samples	Radioactivity levels Bq/kg						
	K-40		Ra-226		Th-232		Cs-137
	range	mean	range	mean	range	mean	range
Soil:	58.02-382.98	180.04	14.82-26.65	22.09	3.91-20.99	10.27	0.64-4.41
Sediment:	4.5-25	11.43	2.34-9.80	5.47	0.6-2.13	0.92	-

The radionuclide which detected in different kinds of water resources and biological samples was potassium-40, in the water samples giving the following activities:

radionuclide	Water resources (Bq/l)					
	Sea water		Ground water		Romanian well	
Potassium-40	range	mean	range	mean	range	mean
	14.85-21.17	15.87	3.35-13.60	7.59	3.2-12.6	6.53

In ground water samples, the highest concentration of K-40 was for the samples collected from the piezometer closest to the sea (piezometer-91) this may be as a result of the intrusion of seawater to the ground water. The results of piezometers have shown the same rational for the sawani water samples, where the lowest K-40 concentrations is found for sawani Samalous (Wg10 toWg-12) which is farest from the sea water.

The Rainwater is found to be free from K-40, whereas some of the surface water samples, which is rainwater stored in reservoirs in the earth (Romanian wells), contained K-40. with low concentrations. This might have resulted from that rain water washes the earth and rocks, and in particular the soluble salts of potassium, on its way to the earth and rocky reservoirs

The biological samples, containing potassium-40 with the following activities:

Biological samples									
Fig		Olive		Flora		Fish		Milk	
range	mean	range	mean	range	mean	range	mean	range	mean
329.5-488.9	442.1	297.1-562.4	364.7	20.948.7	39.6	149.7-490.7	357.3	194.7-508.7	387.5

The results show that the average specific activity of K-40 in figs is higher than olives by almost 21%. The flora (seaweed) exhibited the lowest K-40 specific activities. The reason could be the continuous washing of the water soluble potassium salts in these weeds by seawater.

The fish, not like fish from the fresh water lakes with some low specific activities for the Ra-226 series and Th-232 series, and sometimes Cs-137; this seawater fish does contain K-40 as the only detectable gamma emitter nuclide

The estimated average values of radium equivalent Ra_{eq} for different soil samples in area under investigated were calculated. These values range from 33.58 to 85.61 Bq/kg with average value 50.71 Bq/kg which is lower than the recommended maximum value 370 Bq/kg.

The absorbed dose rate has been calculated and knowing the values of dose conversion factors 0.043, 0.427, and 0.662(nGy $^{-1}$h (Bq kg^{-1})" for ^{40}K, ^{238}U and ^{232}Th respectively. the values range from 15.53 nGy/h at S-18 to 41.51 nGy/h at S-12 with average value of 24 nGy/h which is agreement the data published in UNSCEAR (1988), The value of dose rate in the investigated soil is lower than the average value (55 nGy/h).

Effective dose for soil samples is calculated by using effective dose factor 0.7 Sv Gy^{-1} to convert the gamma absorbed dose rate in air into an effective dose using UNSCEAR report (1988). Where, its ranged from 95.29 to 254.73 μ Sv y^{-1} with an average value of 147.31μ Sv y.$^{-1}$

In the second part, chapter I, the introduction, dealing with description of the statigraphy, geology, hydrology for site location.

Chapter II, experimental work, in this chapter, the description for instrumentation, which used for chemical and environmental isotopes (oxygen-18 and deuterium) as well as radioisotope (tritium) were elaborated. These instruments include, ion chromatograph, liquid scintillation and isotope ratio mass spectrometer. Calibration and adjustment of these instruments were described.

Chapter three, results and discussion, this chapter subdivided into two parts: the first one, dealing with hydrochemistry of groundwater including different type of water resources (piezometers, sawanis and cisterns). Chemical analysis for major, minor and trace elements took place.

The results of these analyses are represented and expressed by different shapes and forms, to assess the recharge sources, the genesis and quality of groundwater. The results reveal that the total salinity of piezometers ranged from 17191 to 34211 mg/l and ranged from 512 to 8652 mg/l in sawanis and cisterns. The piezometers show the cationic and anionic sequences as $Na^{+}>Mg^{2+}>Ca^{2+}>K^{+}$/Cl. $>SO_4^{2-}>HCO_3>CO2$. This sequence reflects chemical water type, which is sodium chloride, these results show that the water mainly Cl- and SO_4^{2}- hyper saline, which reflect the lithologic formations around as well as the water migrating through the fracture system in the limestone. The high Cl in this water may be due to intrusion with seawater or the washed salts from the surface during the rainfall and its penetration downward to the aerated zone of the ground. The salinity is also increased due to evaporation, when the water table is shallow.

The changes in the chemical composition of the ground water could occur through mixing between waters of different origins, chemical interaction between aquifers, rocks and water, as well as evaporation of the shallow ground water. The chemical interaction in the study area could occur between water and calcite, which are the main minerals of the limestone. For other type of water samples (Sawanis and cisterns), large physical and chemical variation are shown. Individual element concentrations also vary and most samples have cationic sequence $Na^{+}>Mg^{2+}>Ca^{2+}$ which represent 70.58% and $Na^{+}>Ca^{2+}>Mg^{2+}$ represent 23.52% meanwhile $Ca^{2+}>Na^{+}>Mg^{2+}$ represent 5.88%. On the other hand , for anionic sequence $Cl->SO_4^{2-}>HCO_3$ represent 41.17% and $Cl^{-}>HCO_3^{-}>SO_4^{2-}$ represent 41.17 meanwhile $HCO_3^{-}>Cl^{-}>SO_4^{2-}$ represent 11.76% and 5.82% represented by the anionic sequence $SO_4^{2-}>Cl^{-}>HCO_3^{-}$. Analysis of minor and trace elements give more information about ground water in addition to, the importance of these metals that may be toxic and their accumulation in body is harmful and may have carcinogenic effect. The results could be compared with the value of normal seawater in (mg/l). which are Zn(0.01), Cu(0.003), Pb(0.003), Cd(0.0001), Mn(0.002) and Fe (0.03). The comparison indicates the enrichment of Zn, Pb, Cu, Mn individually in all piezometers. The plotted data in piper diagram clarify that piezometers water characterized by primary salinity.

Tritium concentrations in the groundwater range from below detection limits (BDL) to 7.25 T.U. in Gimmima area, from BDL to 1.94 TU in Samallos area, from BDL to 3.32 TU in Gaber area, from BDL to 12.49 TU from Giffera area and in site area from BDL to 11.96 TU. Distribution of ^{3}H values of the groundwater samples does not show a definite pattern and show large variation of tritium content between different groundwater in El Dabaa region including different areas as; Gimmema, samallos, Gaber, Geffera and site area provide insight into natural of aquifer in study area and indicate the high degree of inhomogeneity of aquifer and different recharging conditions due to permeability variation of bearing formations. All samples of site area have low tritium contents except sample No (24) it has considerably high tritium content 11.96 TU. The reason may be due to the location of this well in the valley surrounded by the ridges that lead to replenishment with water enriched in tritium due to evaporation. On the other hand, the same variation in tritium contents are found in Geffera area where samples No. (14) with value of 12.49 TU indicates groundwater recharge from modern rainfall in Modern recharge consists of groundwater in equilibration with an atmosphere contaminated by nuclear weapons testing initiated around 1953. On the contrary, sample number 16 shows tritium content below detection limit indicating very low permeability and long of residence time of ground water the same variation in tritium content clear in all region in El Dabaa area. In seawater, tritium concentration has been determined at four locations for different season to cover all changes that may be occurring due to seasonal variation. Selected locations were e stablished t o r epresent t he suggested area for inlet and outlet cooling channel for suggested pressurized water reactor type (PWR). The average values for four locations were 2.55±0.76, 1.28±0.74, 3.14 ±0.77and 2.21±0.76 TU for WS1, WS2, WS3 and WS4 respectively with the mean average value 2.30 ±0.76TU. In case of surface water (Romanian wells), the results clarify the maximum value of 11.3±1.3 TU at WR3 and minimum value of 2.78± 0.8 at WR5 with average value of 6.87 ±0.86 TU.