Chapter III
Results and Discussion

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3.1 Environmental surveillance

There are several models to predict distribution of radioactivity from release point using several assumptions about the release rate, the dispersion phenomena and the distribution behaviour of radionuclides in the differential environmental compartments. Environmental surveillance programmes need to ensure compliance with the national regulations on water quality, air pollution, waste management and land use following the legal/or regulatory requirements. They also aim to monitor eventual occurrence of radionuclides in food, soils and crops, and to provide records on preoperational and postoperational environmental conditions regarding the major nuclear facilities with detailed information about the background radiation levels, wild life, vegetation and fisheries, and to provide monitoring services in emergency situations.

The main elements of environmental surveillance programmes are based in principle on radiation measurements within the area of any nuclear facility where the study of the natural radiation background is essential for the purpose of establishing radiological reference base line. This is considered the first step in any local or national monitoring programme (45) and, the ecological observations in areas which are directly affected by such a facility. Also, among the important tasks in environmental surveillance, the measurement and identification of beta and gamma emitters and low level radioactive contaminates in air and water samples from selected locations, and the determination of iodine-131 cesium-137 and strontium-90 and any other radionuclides in crops or local food products are essential. The most viable programmes attempt to select the sampling points and frequencies that might provide the most relevant information following local conditions about the type of nuclear facilities, the physical and chemical characteristics of released radionuclides and their environmental behaviour.

The prevailing environmental features in the area are also important, particularly the climatic conditions, topography, geology, hydrology,

hydrography, and vegetation cover. Human activities in agriculture, fisheries, water, food supplies, and industry as well as the population distribution and habits prevailing in the area under consideration play significant role in sampling. The collection of these information assist in the identification of the principle exposure routes, the potentially hazardous radionuclides and the mostly affected group of population.

To design an adequate surveillance programme, it is important to define very clearly its main objectives and continuous monitoring would have to be extensive and regular. Protection of people is the overriding design objective and the programme needs to be capable of anticipating any hazard situation that may rise from a sudden release of radioactivities and to incorporate emergency measures, including means of notification of any threatened group of population and to set appropriate plan for evacuation, whenever decided. Several type of measurements need to be carried out providing for continuous measurements at selected locations. The most significant locations can be defined through detailed knowledge of the area under consideration and by using the model pathways derived from theoretical dispersion calculations. The system needs to specify the type, number and frequency of measurements as well as sample size and methods of analysis.

The level of radionuclides in food and environmental samples are exceedingly low and need high sensitivity nuclear measuring systems. Elaborate calibration is always need using reference standards similar to the test samples. A recent IAEA publication (46) summarizes the applicable techniques for collection of representative samples from different environmental compartments, recommend procedures for destructive and non destructive measurements and specific methods for determination of iodine-131, strontium-90, tritium, cesium-134 and 137 isotopes using different types of detectors, counters and data recording systems.

In most cases, air samples collected at regular flow through a number of filters (e.g. charcoal filters are commonly used to collect iodine). In other cases, collection trays and containers are used to collect rainwater with

horizontal platform covered with gummed acetate to hold heavy particles fallouts. The gummed acetate sheets are ashed and counted for gross beta activity and the air filters are analyzed for both beta and gamma activities, while charcoal filter analyzed for radio-iodine by appropriate gamma spectroscopy. Collected rainwater, on the other hand, is normally analyzed for gross beta, specific gamma and strontium-90 levels. Special procedures have been also applied for the determination of tritium and the radioisotopes of nobel gases in rain water (47)

For water analysis, periodic samples are normally collected from different water resources at suitable time intervals. A number of concentration methods are usually elaborated, based on separation of the suspended matter followed by ion exchange separations. The radionuclides which are commonly determined in rain water include, iodine-131, -133 cesium-134,-137 strontium-90, iron-59, ruthenium-106, cobalt-60 and manganese-54.

Soil analysis is mainly concerned with the determination of the long-lived radionuclides strontium-90 and cesium-137 which accumulate in different soils through precipitation over many years. Also the naturally occurring radionuclides potassium-40, thorium-232, uranium-238, radium-226 and their natural decay product are present. The common procedure for analyzing soil samples, involve either gamma ray spectrometry of dried samples (using certified reference soil samples) or by wet radiochemical procedures specific for determination of strontium-90. Soil samples are generally collected once or twice a year in the sectors with the highest probability of deposition, preferably in the vicinity of food crops.

Emergency surveys depend largely on the type and level of the nuclear accident under consideration. Detailed information about the meteorological and hydrological conditions in the area and the feature of the released radioactivity will assist to pinpoint locations to obtain meaningful measurements. Immediate surveys must establish the extent, direction and characteristic of radioactive release, its associated ground level dose and the projected pathways where soil deposition and water contamination occurs.

Long term measurements need to deal with contaminated pasture and its probable effect on milk and livestock, contamination of fish and marine organisms and the radioactivity levels in streams and water resources. In all cases, simplified surveillance programmes need to be well designed and elaborated to meet the national regulations and assure safety of population. Plan for emergency survey based on both immediate and long term measurements need to be also considered and to be always ready for implementation.

3.2 Radioactivity measurements

Several studies reported for the naturally occurring radioactivity in soil and sediments which including Ra-226, Th-232 and K-40 and giving the values of 26, 14 and 330 Bq/Kg respectively for sedimentary sandstone formation, and 16, 5 and 80 Bq/Kg for limestone (48). In Egypt, there are some studies in different areas dealing with measuring naturally occurring radionuclides in different environmental samples.

EL-Arabi et al (49) studied the concentrations and distributions of natural radionuclides occurring in rocks. The activity concentrations (Bq/kg) of the naturally occurring radionuclides ^{226}Ra, ^{232}Th, and ^{40}K in sedimentary rock samples from Eastern Desert (Um El-Huetat), Nile Valley (Gebel Owina) and from southwest Sinai (Wadi Ghweiba) were measured using a high-purity germanium detector. The samples under investigation (clay, shale and sandstone) were used as raw materials in the construction industry (bricks, ceramics, cement, fillers, etc.).. The average concentration values of 226 Ra, 232Th, 40K were 47±7, 21±5, 393±19 Bq/Kg(caly); 23±5, 30±6, 563±24 Bq/Kg (shale); 17±4, 14±4, 299±17 Bq/Kg (sandstone), respectively. All sediment samples have radium equivalent activities ranging from 55 to 115 Bq/Kg, lower than the limit set in the OECD Report (370 Bq/Kg). The overall mean outdoor terrestrial gamma dose rates fluctuate from 28 to 55 nGy/h. The external gamma radiation dose due to natural radionuclides present in the samples have been computed and compared with the global averages. In terms of the radiation safety, the natural radioactivity of the

sediment in Egypt is below the recommended limits of the gamma dose rate. Therefore, they can be used for all kinds of public buildings.

Higgy (50) determined the specific activity for U-238, Th-232, K-40 Cs-137 in Sfaga Red Sea. To assess radiological hazard to the patients treated by climatotherapy from Psoriais and Rheumatoid Arthritis. The samples were collected for a different period from climatotherapy area in Safaga including, soil, sea water, surface sediment from shore. And other comparison samples were collected from Hurgada. Samples dried at 100^0C, mixed and sieved through 2 mm mesh. The results showed the radioactivity present due to natural radioactive chain U-238, Th-232 beside other primordial nuclides such as K-40, Cs-137, Pu-238, P239-240 in some samples due to radioactive fallout. The activity concentration for U-238, Th-232 similar to terrestrial rock (range from 1.5-80 Bq/Kg) for all samples except surface sediment ranging from 76.6 to 225 Bq/Kg for U-238 and 88 to 401 Bq/Kg for Th-232. This due to heavy grain resulting from bulder clay glacial period (51). This result from enrichment of heavy sand grains with high heavy minerals concentrations result from the boulder clay glacial period, Th-U-238, Th-232 concentrations are partly rather high.

Saied et al (52) measured the natural radioactivity in some geological samples, located in Wadi Qena, Upper Egypt, by a gamma spectroscopic method (NaI(Tl)). That the region was found to have a higher natural background than other regions in Upper Egypt. Sixty five granite samples with different ages were collected from the granitic rocks of the G.El Missikat and El Garra areas. The sample dried at 105 °C and sieved to 50 mesh. The activity of U-238 was determined from its daughter ^{214}Bi while for Th-232 The activity measured from daughter ^{228}Ac and ^{208}Tl and K-40 measured directly. The results show the activity of U-238 ranged from 0.02 and 0.05 Bq/g while varies from 0.03 to 0.22 Bq/g Th-232 and from 0.14 to 2.00 Bq/g for K-40 showing increasing in concentration of Th-232 than U-238 in all granite samples.

El-Sayed et al (53) developed a γ-spectroscopic approach for assessment of natural radioactivity levels in different environmental samples.

Non destructive γ-ray spectroscopy measurements have been elaborated to assess radioactivity levels of naturally occurring potassium-40, uranium-238, radium-226, thorium-232 and man made cesium-137 radioisotopes in water and sediment samples collected from different sites along Ismaillia Canal and Berket Karoun areas. The results showed that the radioactivity levels of uranium, radium and potassium are almost 1.5 times higher than in sediments collected from Berket Karoum than those from different location along Ismalia Canal; thorium has a reversed trend. The mean radioactivity levels in sediments of berket Karoun in (Bq/Kg) are 973 for K-40, 94 for uranium/radium, 52.5 for thorium and 3.5 for cesium-136. The respective mean radioactivity levels in water samples (in Bq/l) are 15 for K-40, 1.5 for uranium/radium and 2.7 for thorium. The complete absence of cesium-137 was assured in aquatic systems of both Ismailia Canal and Berket Karoun.

El Farrash et al (54) measured concentration of natural radioactivity (Th-232 series, U-238 series and K-40) in isolated sand hills (geziras) in eastern Nile Delta using gamma-ray spectroscopy system. The results reveals that, for most of the sandy samples, K-40 concentrations are much higher than that both U-238, Th-232. The highest values of U-238, Th-232 and K-40 activity concentrations were found to be 16.63, 11.27 and 263 Bq/Kg and their lowest values 0.81, 0.4 and 32.36 Bq/Kg respectively.

3.2.1 Radioactivity measurements in soil and sediments

The study of radiological baseline in the site selected for construction the first nuclear power plants in Egypt is main target. To assess this purpose, naturally occurring radionuclides in different environmental compartments should be determined to detect any variation which may be occur due to nuclear accident or test nuclear weapon. Where, the soil is part of geosphere which is directly exposed to environmental conditions and gets most affected by any changes in these condition

In present study, twenty five soil samples have been collected from twenty five locations within concerning area, the uranium-238 and its decay series is our concern, in addition to, Cs-137 and K-40. For Ra 226 (uranium-238) the energy lines which might be referred to quantitative measurements,

include: 295 and 352 KeV for lead-214 and 609, 1121, 1764 KeV of Bi-214. The selection of these gamma lines due to their abundance, the abundance of gamma ray lines 295.231 KeV, 251.92 KeV, 609.31 KeV, 1120.9 KeV and 1764.49 are 19.7%, 38.90%, 43.3%, 15.7% and 17% respectively. Also, the gamma ray lines at 661 KeV, 1461 KeV can be used to assessment of cesium-137 and potassium-40 which have abundance 85.231 and 10.70 respectively. For thorium-232, on the other hand, the selected photopeaks of gamma ray lines mostly used for γ-ray measurements include those at 238.63 KeV, for lead-212, 583.19 KeV for thalium-208, 338.4 KeV, 911.07 KeV and 969.11 KeV for actinium-228 whose relative percent abundance values are 44.6 %, 85.77 %, 11.40 %, 27.7 % and 16.6 % respectively.

Table (3-1), illustrates the radioactivity levels of (Ra-226) uranium-238, in soil samples from 25 locations within El Dabaa area. The level of Ra-226 ranges from 14.82 Bq/Kg at S-8 to 26.56 Bq/Kg at S-6 with the average of 22.09Bq/Kg. These data are further illustrated in Fig. (3-1), which clarify the distribution uranium-238 in soil samples in different locations within El Dabaa area.

For thorium-232, Table (3-2) illustrates radioactivity levels which range from 3.91 Bq/Kg at S-18 to 20.99 Bq/Kg at S-2 with average 10.27 Bq/Kg. These data are further illustrated in Fig. (3-2), which clarifies the distribution of thorium-232 in different locations within El Dabaa area. In case of potassium-40 and cesium-137, Table (3-3) clarified that the radioactivity levels of K-40 range from 58.02 Bq/Kg at S-12 to 382.98 Bq/Kg at S-2. with average of 180.04 Bq/Kg, and it is notified that Cs-137 only detected in a few samples and range from 0.64 Bq/Kg at S-20 to 4.41 at S-13. Fig. (3-3) Shows variation levels of potassium-40.

Table (3-1): radioactivity levels of (Ra-226), uranium-238, in soil samples from different areas within El Dabaa site*)

nent	(Ra-226), uranium-238(Bq/Kg)					
ope	Lead-214		Bismuth-214			mean
rgy,KeV	295.21	351.92	609.31	1120.29	1764.49	
nsity,%	19.7	38.90	43.3	15.7	17	
ıtion	radioactivity levels in soil samples, Bq/Kg					
plecodes**)						
S-1	24.54	24.12	24.92	25.167	27.43	25.23±1.78
S-2	28.16	24.68	26.02	24.99	26.69	26.11±0.9
S-3	24.60	22.83	23.77	22.80	26.92	24.18±2.87
S-4	22.88	22.30	23.37	24.00	25.27	23.57±1.78
S-5	23.19	21.54	22.60	25.11	23.45	23.18±0.55
S-6	25.25	24.92	26.89	27.14	28.60	26.56±0.77
S-7	20.50	19.08	19.71	18.91	21.02	19.84±0.73
S-8	15.26	13.68	14.83	13.69	16.72	14.82±1.71
S-9	19.69	16.64	17.75	17.10	20.56	18.35±0.99
S-10	20.32	17.85	18.63	18.65	19.96	19.08±0.79
S-11	22.55	22.14	23.41	23.56	25.95	23.52±2.99
S-12	24.71	24.15	25.75	25.22	27.20	25.32±0.89
S-13	25.63	24.56	24.23	25.09	28.26	25.86±0.85
S-14	23.29	22.81	24.60	24.84	24.81	23.99±1.80
S-15	25.56	22.85	24.63	22.74	26.09	24.37±0.85
S-16	24.13	23.21	24.63	23.73	25.86	24.31±0.77
S-17	20.32	18.28	18.86	18.74	17.94	18.30±0.84
S-18	22.55	19.45	19.43	20.26	22.59	20.49±0.61
S-19	24.71	22.72	22.74	23.31	25.00	23.04±1.16
S-20	25.63	20.34	19.88	19.48	23.13	20.89±0.96
S-21	23.29	22.57	22.42	25.27	22.95	23.40±1.21
S-22	25.56	16.37	16.25	17.94	17.62	17.35±0.97
S-23	24.19	24.35	25.65	24.11	27.05	24.97±0.81
S-24	21.21	14.55	14.31	15.91	16.34	16.64±0.78
S-25	22.67	22.51	23.61	23.98	25.52	23.66±0.94

anium 238 was determined by measuring the gamma-energy lines at 295, 352KeV of lead-214, and 609, 1121, 4 KeV of bismuth-214. Determinations were carried out through activity measurements by HPGe with efficiency 0% and FWHM of 1.78 at 1.33 MeV.

see figure (2-1)

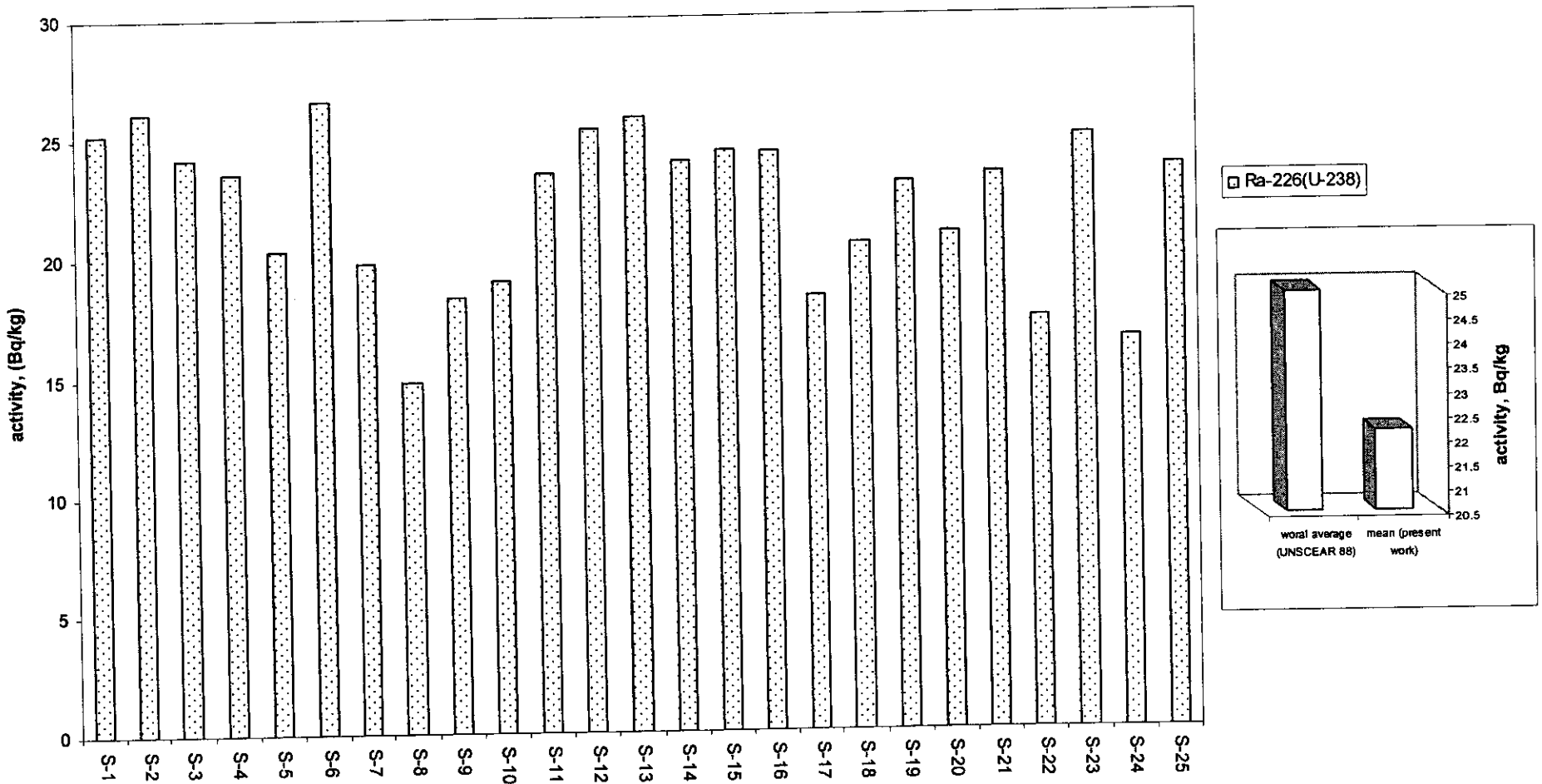

Fig. (3-1) mean activity level of Ra-226(U-238) in soil samples from different locations within El Dabaa area

Table (3-2): radioactivity levels of thorium-232, in soil samples from different areas within El Dabaa site*)

element	thorium-232(Bq/Kg)					
isotope	pb-212	Ac-228	Tl-208	Ac-228	Ac-228	mean value of Th-232
energy, KeV	238.63	338.4	583.19	911..07	969.11	
intensity,%	44.6	11.4	85.77	27.7	16.60	
location	radioactivity levels in soil samples, Bq/Kg					
sample codes						
S-1	10.13	5.88	1.91	6.52	9.94	6.88±0.75
S-2	26.38	20.36	6.99	22.45	28.77	20.99±1.32
S-3	18.27	12.76	4.77	15.15	22.00	14.59±1.05
S-4	15.49	11.05	3.88	12.69	16.86	12.00±0.87
S-5	10.01	6.55	2.88	9.11	10.55	7.82±1.64
S-6	8.52	4.05	1.39	5.35	6.84	5.52±0.73
S-7	17.67	13.38	4.79	15.60	15.80	13.53±0.68
S-8	13.32	11.12	3.42	11.01	15.38	10.85±0.91
S-9	15.60	11.68	4.21	13.14	17.65	12.45±1.24
S-10	19.79	14.48	5.02	15.81	22.25	15.47±1.16
S-11	14.38	10.90	3.57	12.85	7.16	11.77±1.23
S-12	7.46	4.15	1.32	4.24	5.70	4.57±0.76
S-13	15.42	11.20	3.63	11.68	16.12	11.61±0.93
S-14	10.83	7.09	2.31	8.39	10.60	7.84±0.84
S-15	19.91	15.08	5.39	17.34	22.99	16.14±1.18
S-16	11.68	9.12	2.59	8.51	12.33	8.85±0.85
S-17	8.28	10.26	3.71	11.79	8.89	8.59±0.69
S-18	1.81	4.78	2.07	5.90	5.00	3.91±0.48
S-19	7.92	8.82	3.74	10.83	8.700	8.00±1.1
S-20	10.78	12.34	6.38	17.31	17.10	12.7±0.94
S-21	7.25	8.98	6.44	10.52	7.41	8.12±1.08
S-22	6.82	8.86	4.58	13.67	11.15	9.02±0.77
S-23	5.04	8.18	2.57	7.86	7.11	6.15±0.6
S-24	10.13	7.21	2.10	7.15	11.05	7.53±0.97
S-25	8.31	7.09	1.41	5.14	4.28	5.28±0.77

*)thorium 232 was determined by measuring the gamma-energy lines at 238KeV of lead-212, 338KeV of Ac-228 and 583 KeV of Tl-208 and. other two peaks 911 and 969 KeV for Ac-228. Determinations were carried out through activity measurements by HPGe with efficiency of 30% and FWHM of 1.78 at 1.33 MeV.

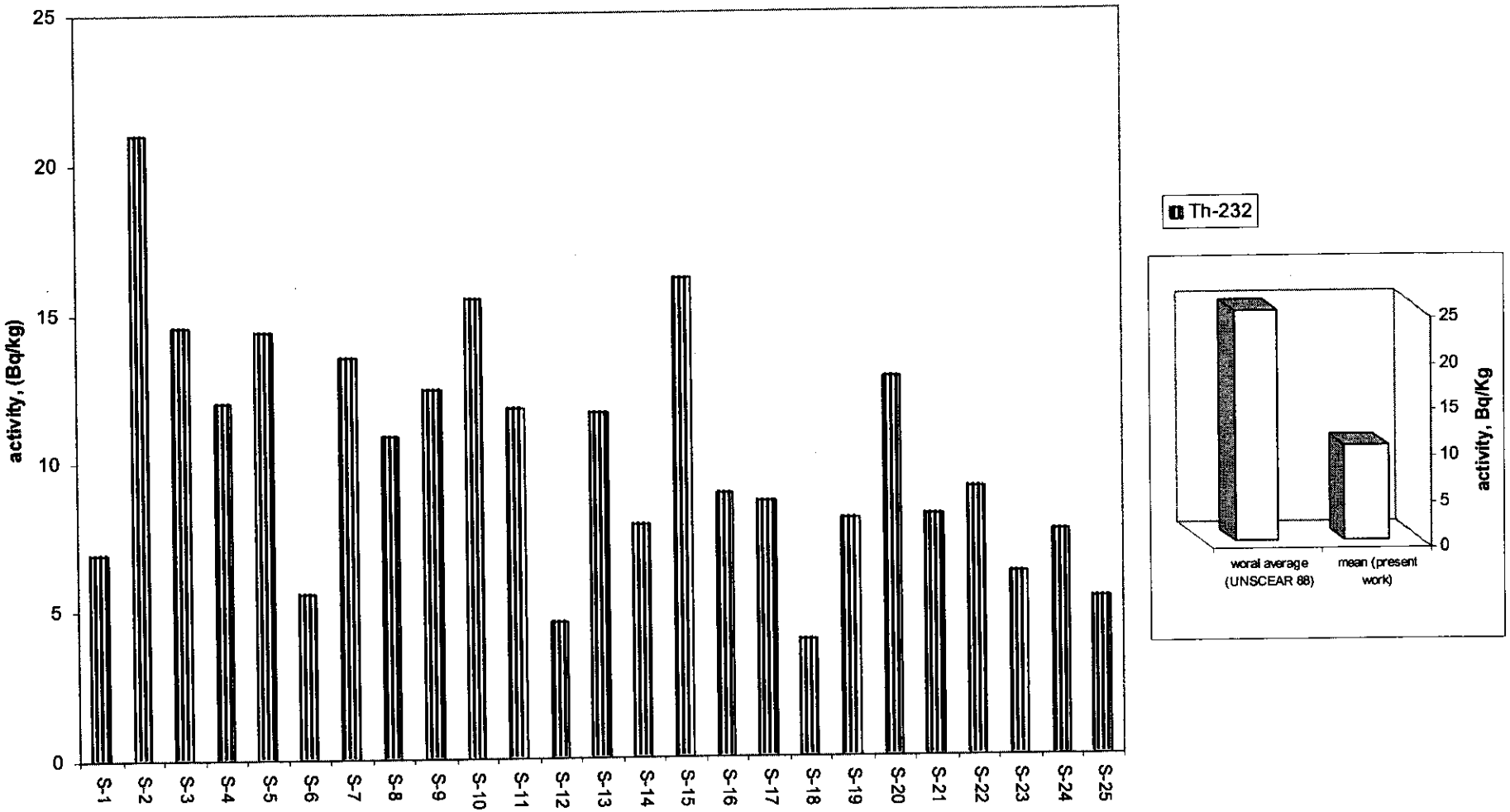

Fig. (3-2) mean radioactivity level of Th-232 in soil samples from different location in El Dabaa area

Table (3-3):radioactivity levels of potassium-40 and caesium-137 in soil samples from different areas within El Dabaa site*)

element	Potassium-40	Caesium-137
isotope	K-40	Cs-137
energy, KeV	1460.75	661.66
intensity, %	10.70	85.21
location	radioactivity levels in soil samples, Bq/Kg	
Samples codes		
S-1	81.70±1.59	1.23±0.11
S-2	382.98±3.52	< DL**
S-3	252.72±2.83	3.44±0.17
S-4	180.77±2.28	2.37±0.14
S-5	237.00±3.80	<DL
S-6	68.81±1.44	< DL
S-7	172.25±2.15	< DL
S-8	185.80±2.41	< DL
S-9	214.82±3.31	< DL
S-10	382.97±4.17	< DL
S-11	190.07±2.93	< DL
S-12	58.02±1.45	< DL
S-13	132.35±2.01	4.41±0.16
S-14	111.76±1.83	< DL
S-15	294.17±3.06	< DL
S-16	102.89±1.80	1.48±0.13
S-17	191.17±2.35	< DL
S-18	97.49±1.20	< DL
S-19	188.99±3.53	< DL
S-20	322.72±3.52	0.64±0.08
S-21	136.27±3.16	< DL
S-22	171.26±2.38	1.47±0.09
S-23	96.61±1.69	1.05±0.08
S-24	160.05±2.22	1.42±0.08
S-25	87.48±1.53	0.99±0.07

*)potassium-40 and cesium-137 were determined by measuring the gamma-energy lines at 1460KeV of K-40 and 661 KeV of caesium-137. Determinations were carried out through activity measurements by HPGe with efficiency of 30% and FWHM of 1.78 at 1.33 MeV.

**) < DL below detection limits. (DL for Cs-137, K-40, Ra-226 and Th-232 are 0.1, 3, 0.7 and 0.6 Bq/Kg respectively)

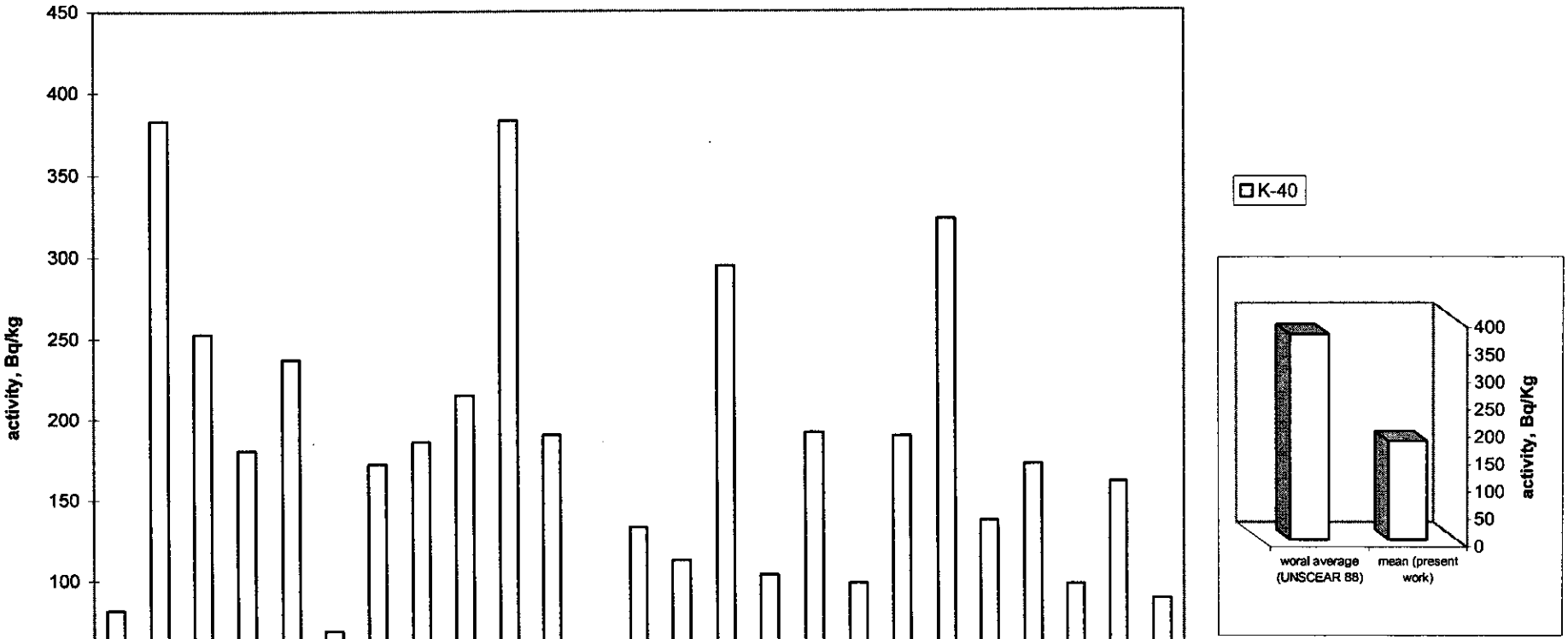

Fig. (3-3) mean activity level of K-40 in soil samples from different location within El Dabaa area

For marine sediment, twenty five samples were collected in investigated area in El Dabaa. The concentration of Ra-226, Th-232 and K-40 are represented in Table (3-4) which shows variation in samples activity which range from 9.80 Bq/Kg at MS-24 to 2.34 Bq/Kg at MS-3 with average of 5.47 Bq/Kg for Ra-226 and range from 2.13 Bq/Kg at MS-13 to 0.6 Bq/Kg at-MS-13 with average 0.92 Bq/Kg for Th-232 in detected samples. Potassium-40 varies from 4.5 Bq/Kg at MS-11 to 25 Bq/Kg at MS-25 with average 11.43 Bq/Kg. These data are shown in Fig,s. (3-4, 3-5, 3-6). The results show homogeneity in activity for soil samples and slight variation of activity in marine sediment samples this may be attributed to similarity in soil samples texture, and variation of organic matter and texture in marine sediment which the latter vary from sand to clay sand and loam sand resulted in two different trend of concentration of radionuclides in marine sediment, the first one, samples from MS-1 to MS-15 which have average specific activity equal to 3.96 Bq/Kg of Ra-226 and 8.08 Bq/Kg of potassium, the second trend, which closely to duplicated value, from samples MS-15 to MS-25 which have average specific activity equal to 6.55 Bq/Kg and 16.62 Bq/Kg for Ra-226 and potassium-40 respectively. Where, the concentration of radionuclides in soil and sediment samples varies according to several parameters as organic matter percent and texture of soil (55). Tables (3-5), (3-6) illustrate the mechanical analysis results for both soil and marine sediment samples respectively.

3.2.2 Water in El Dabaa

The measurements of radioactivity level in El Dabaa site including; different types of water resources as ground water, sea water and rain water by following the same methods for soil samples using HPGe detector with efficiency 30 % and FWHM 1.78 at 1.33 MeV.

In present study, forty four samples of different types of waters were collected from different locations in area under investigation, to measure different activity levels in water samples. The collected samples include; sea water, ground water and cistern water (Romanian well).

Table (3-4) radioactivity levels of uranium238 and thorium-232, in marine sediment samples from different area within El Dabaa site*)

Sample code	Concentration of radionuclides in (Bq/Kg)		
	Ra-226(U-238)	Th-232	K-40
Ms.1	2.88±0.30	0.9±0.30	6.10±0.48
Ms.2	3.72±0.38	<DL	9.58±4.12
Ms.3	2.34±0.18	<DL	8.74±0.96
Ms.4	5.60±0.20	<DL	5.32±0.40
Ms.5	4.92±0.45	<DL	10.21±0.52
Ms.6	4.07±0.48	<DL	10.69±0.66
Ms.7	4.54±0.63	<DL	9.83±1.23
Ms.8	3.80±0.10	0.70±0.10	5.70±0.20
Ms.9	3.70±0.15	<DL	6.90±0.60
Ms.10	5.40±0.3	<DL	9.20±0.80
Ms.11	4.00±0.10	0.60±0.10	4.50±0.20
Ms.12	4.20±0.1	0.70±0.10	7.20±0.40
Ms.13	2.68±0.46	2.13±0.42	9.13±0.96
Ms.14	4.13±0.54	0.84±0.41	9.75±0.74
Ms.15	3.45±0.43	<DL	8.43±0.81
Ms.16	7.20±2.10	<DL	14.90±2.10
Ms.17	8.20±0.50	<DL	15.60±1.90
Ms.18	5.01±0.43	<DL	9.12±0.51
Ms.19	7.20±0.00	0.70±0.40	17.50±1.80
Ms.20	8.20±0.50	<DL	13.60±1.60
Ms.21	7.90±0.90	<DL	20.80±2.50
Ms.22	7.60±0.40	<DL	13.60±2.00
Ms.23	7.50±0.50	0.80±0.30	13.60±1.60
Ms.24	9.80±0.90	<DL	20.80±2.20
Ms.25	8.70±0.80	<DL	25.00±1.70

*)U-238, Th-232 and K-40 were determined by measuring the gamma-energy lines at 1460KeV of K-40 and 661 KeV of caesium-137. Determinations were carried out through activity measurements by HPGe with efficiency of 30% and FWHM of 1.78 at 1.33 MeV.

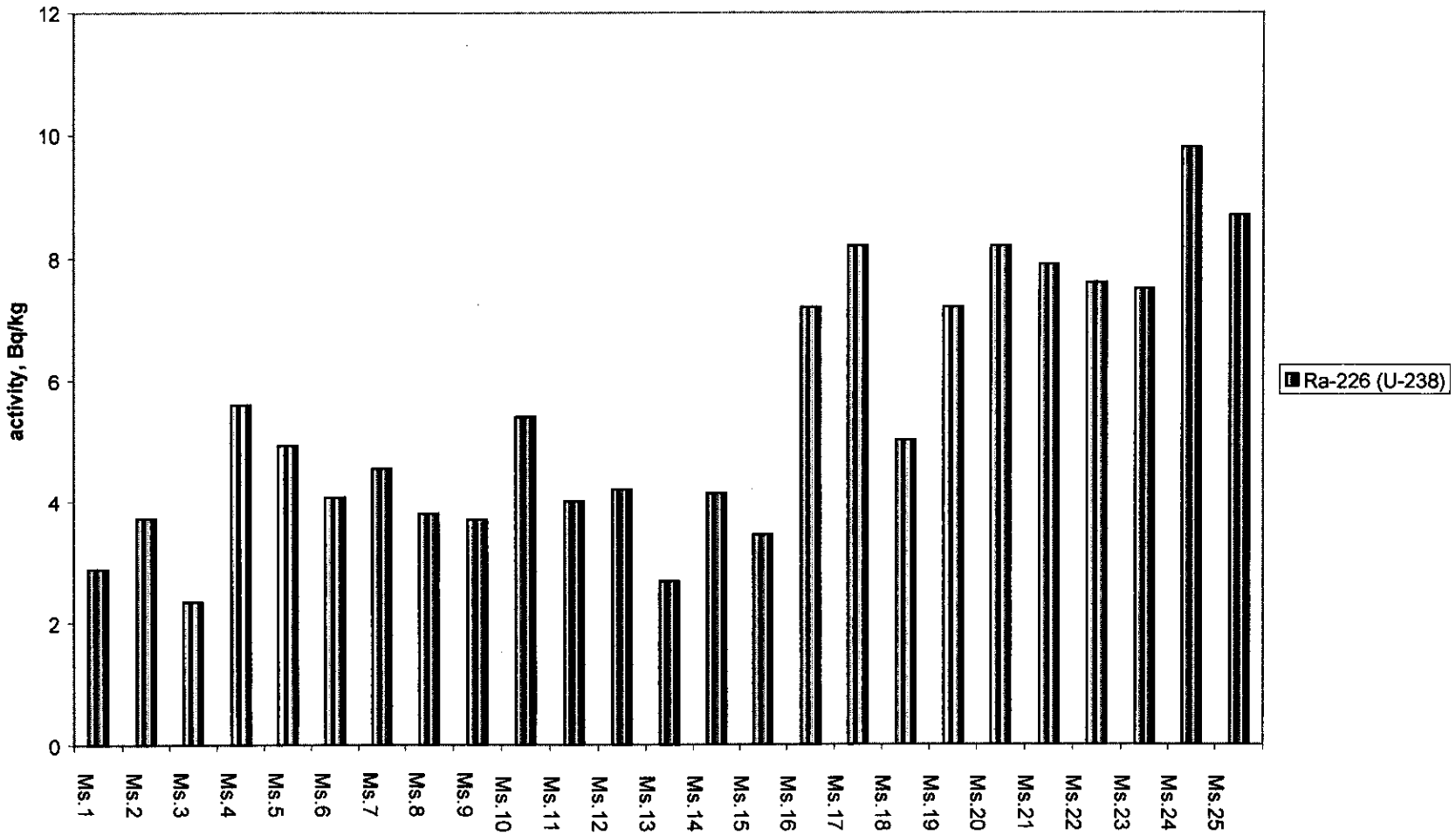

Fig. (3-4) mean activity level of Ra-226 (U-238) in sediment samples

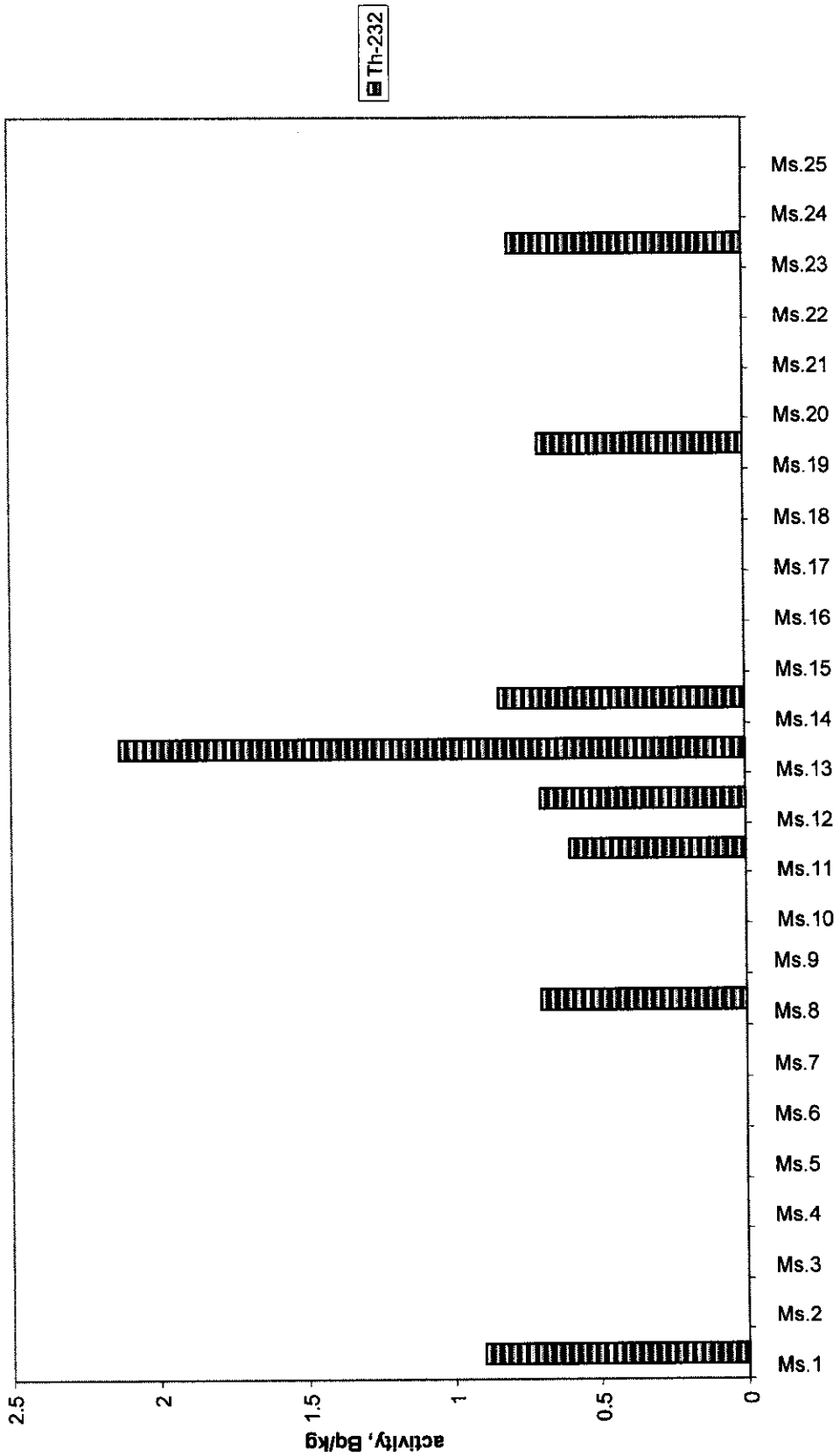

Fig. (3-5) mean activity level of Th-232 in sediment samples

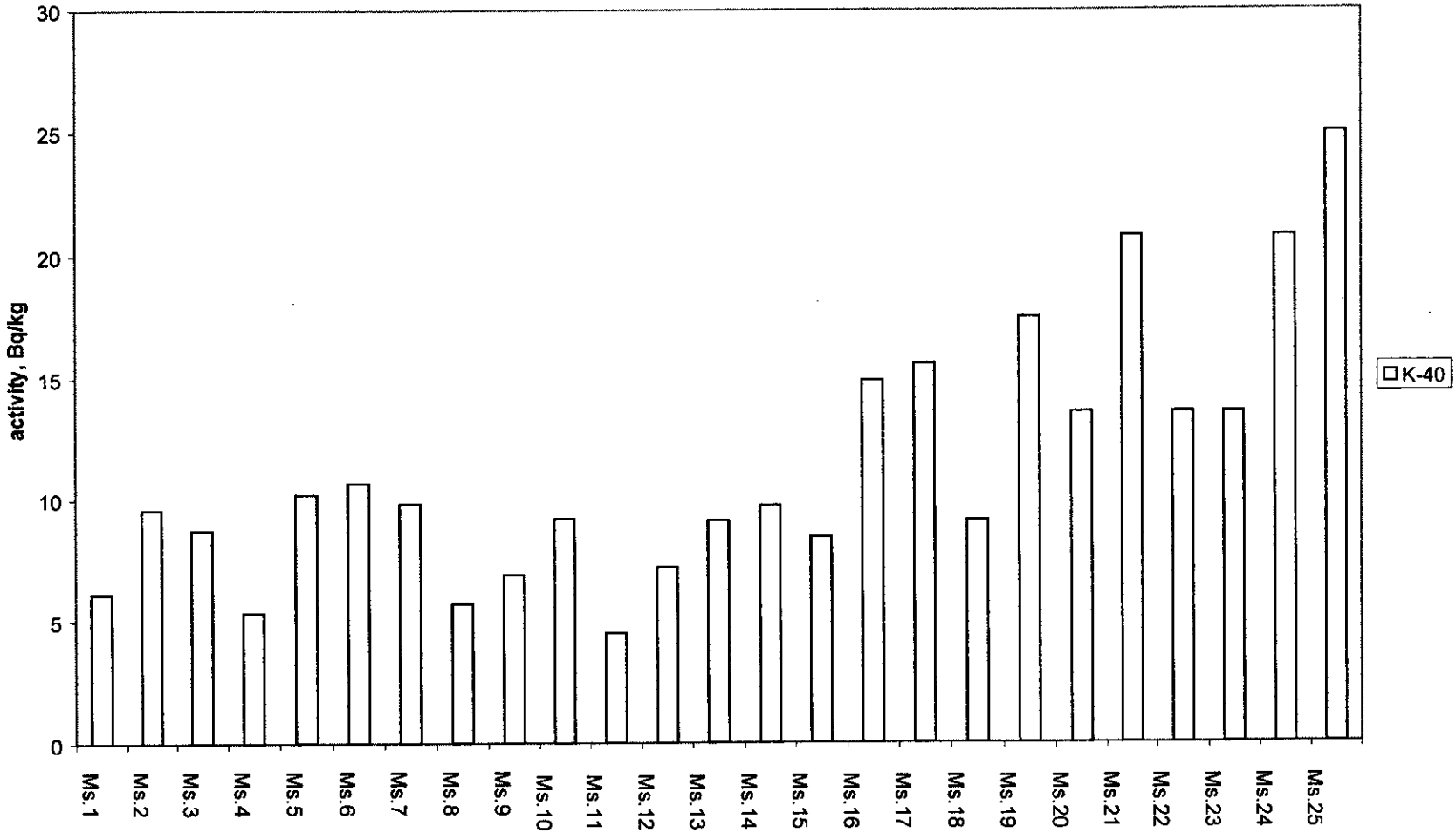

Fig. (3-6) mean activity level of K-40 in sediment samples

Table (3-7) Concentration of K-40 in sea water samples*)

Sample code	Concentration (Bq/l) K-40
Ws.1	12.34±0.62
Ws.2	11.15±0.40
Ws.3	17.43±0.96
Ws.4	17.43±0.94
Ws.5	10.20±0.37
Ws.6	17.43±1.14
Ws.7	10.40±0.90
Ws.8	14.85±0.74
Ws.9	17.43±1.50
Ws.10	21.17±1.33
Ws.11	19.92±1.90
Ws.12	21.17±1.02
Ws.13	16.19±0.95
Ws.14	17.43±0.90
Ws.15	14.94±0.84
Ws.16	16.19±0.82
Ws.17	16.19±0.76
Ws.18	14.94±0.90
Ws.19	14.94±0.81
Ws.20	16.19±0.95

Table (3-8) Concentration of K-40 in ground water samples*)

locations	Sample code	Concentration (Bq/l) K-40
pizometer 91	Wg-1	13.60±0.46
pizometer 92	Wg-2	4.26±0.22
pizometer 93	Wg-3	8.87±0.41
pizometer 94	Wg-4	7.79±1.30
pizometer 95	Wg-5	6.36±0.56
pizometer 96	Wg-6	9.25±0.70
pizometer 97	Wg-7	8.40±0.50
pizometer 98	Wg-8	11.70±0.90
pizometer 99	Wg-9	9.41±0.60
Sawani samalous-1	Wg-10	3.89±0.57
Sawani samalous-2	Wg-11	4.20±0.70
Sawani samalous-3	Wg-12	3.35±0.22

*) K-40 was determined by measuring the gamma-energy lines at 1460KeV. Determinations were carried out through activity measurements by HPGe with efficiency of 30% and FWHM of 1.78 at 1.33 MeV

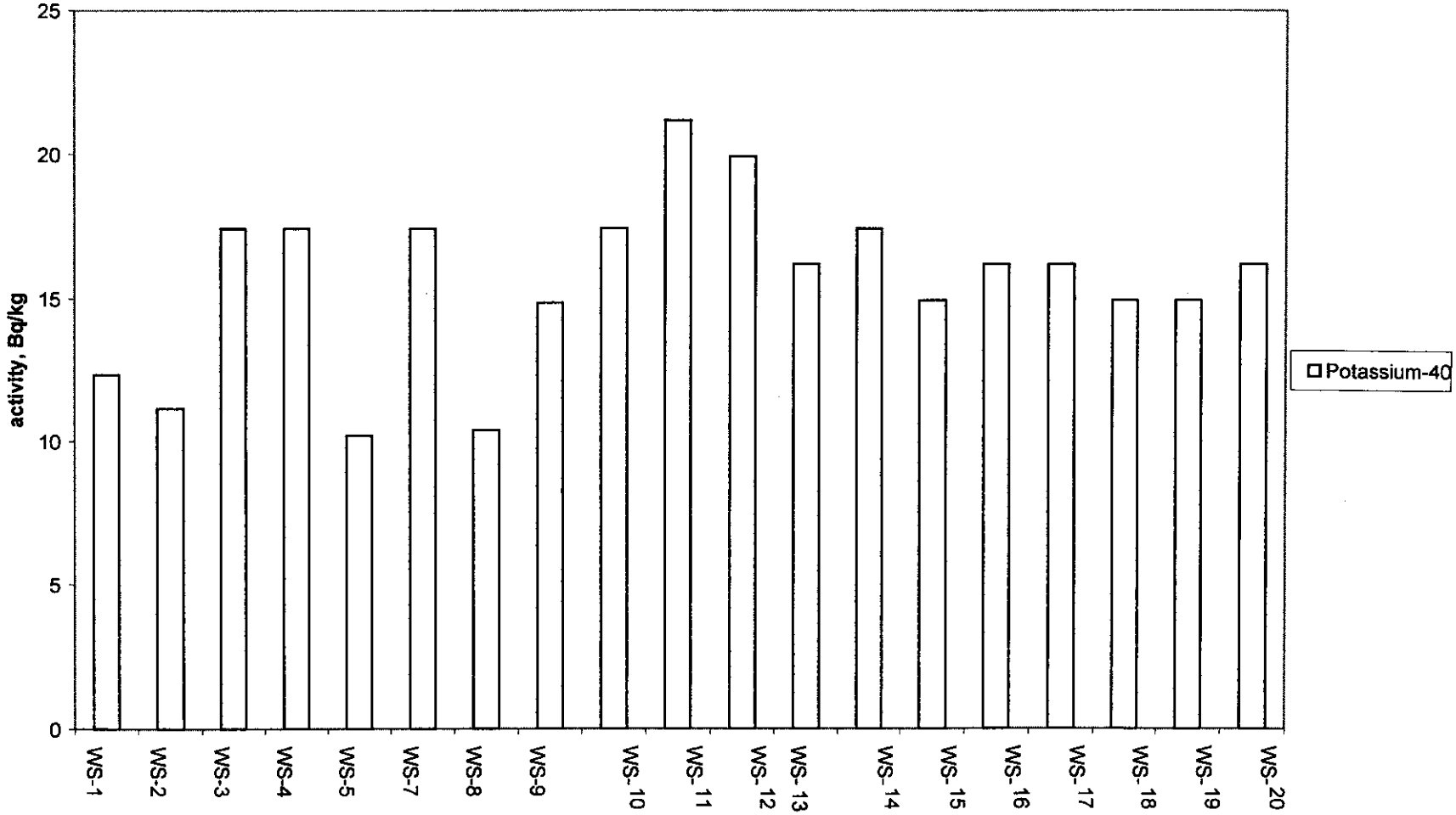

Fig. (3-7)activity concentration of potassium-40 in sea water samples within El Dabaa area

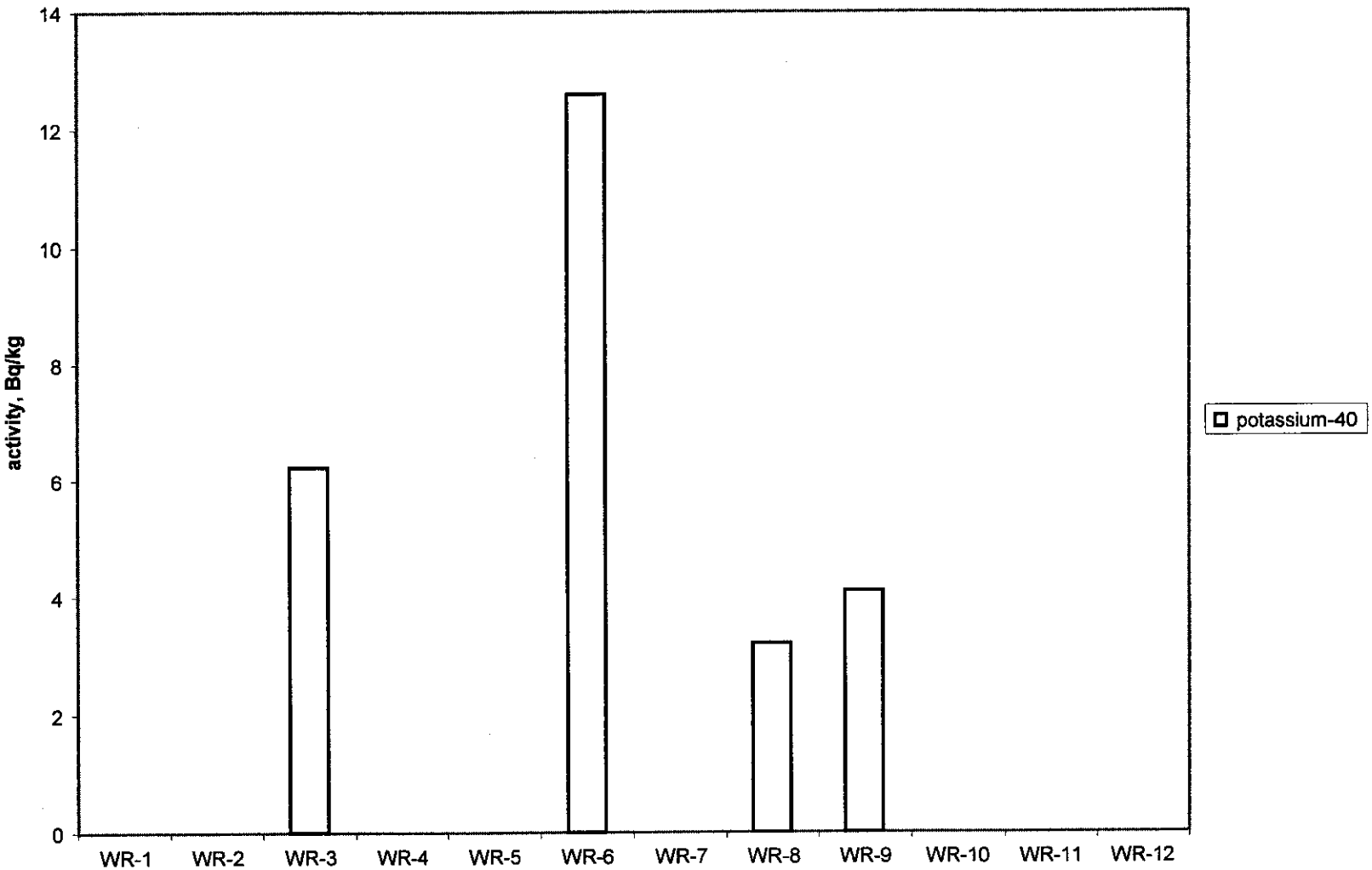

Fig. (3-9) mean activity level of potassium-40 in cistern water within El Dabaa area

minimum in F-3 sample with activity value of 329.5 Bq/Kg and a verage activity of 442.13 Bq/Kg. Olives samples have the minimum and maximum activity in O-5 and O-7 respectively with activity values ranging from 297.1 Bq/Kg to 562.4 Bq/Kg and an average value of 364.66 Bq/Kg. The average specific activity of K-40 in figs is higher than olives by almost 21%. These data are further illustrated in Fig,s. (3-10, 3-11).

ii-Flora, fish and milk samples

The flora activity is also studied and the results are shown in Table (3-12) which clarified that the minimum activity value of 20.9 Bq/l in Fl-3 and maximum value of 48.7 Bq/l in Fl-6 with the average concentration level equal to 39.58 Bq/l, these results are also clarified in Fig. (3-12). Flora (seaweed) exhibit 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 activity levels of potassium -40 in fish samples are listed in Table (3-13), which range from 149.70 Bq/Kg in Fsh-2 to 490.70 Bq/Kg in Fsh-5 with the average concentration level of 357.34 Bq/Kg, these data are shown in Fig (3-13). 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 sea water fish does contain K-40 as the only detectable gamma emitter nuclide (56).

Milk activities were determined, and the results are represented in Table (3-14) range from 194.67 Bq/Kg in M-5 to 508.7 Bq/Kg in M-6 with average of 387.54 Bq/Kg . These data are further illustrated in Fig. (3-14).

3.3 Dose assessment

During past decades, the attention about exposure to natural radioactive particularly U-238, The-232 and K-40 was increased due to the fact that external radiation exposure from naturally occurring radionuclides contribute an average, about half of the average annual dose to the human body from all radiation sources (57). 'The radiation hazard parameters

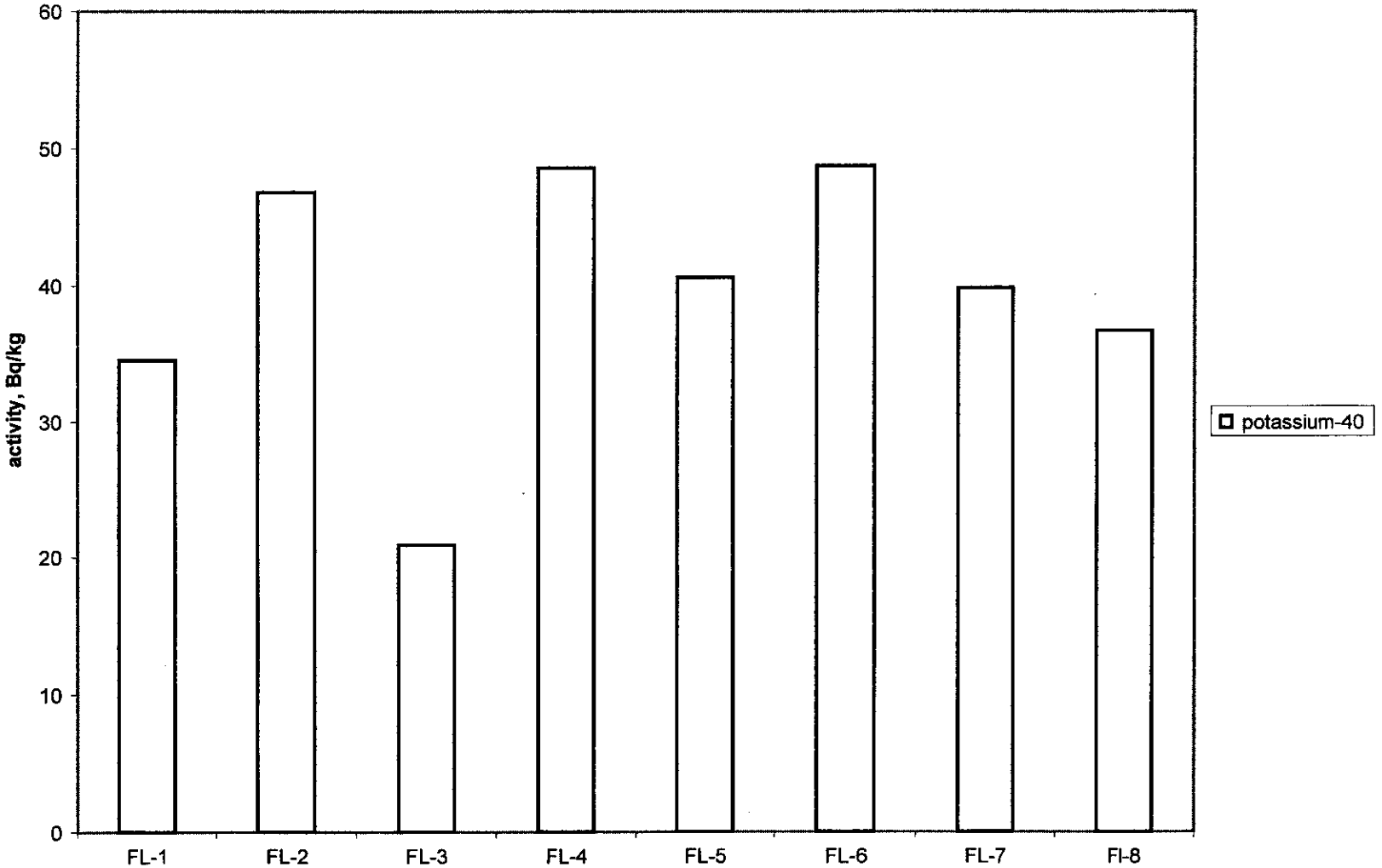

Fig. (3-10) mean activity level of K-40 in flora samples within El Dabaa area

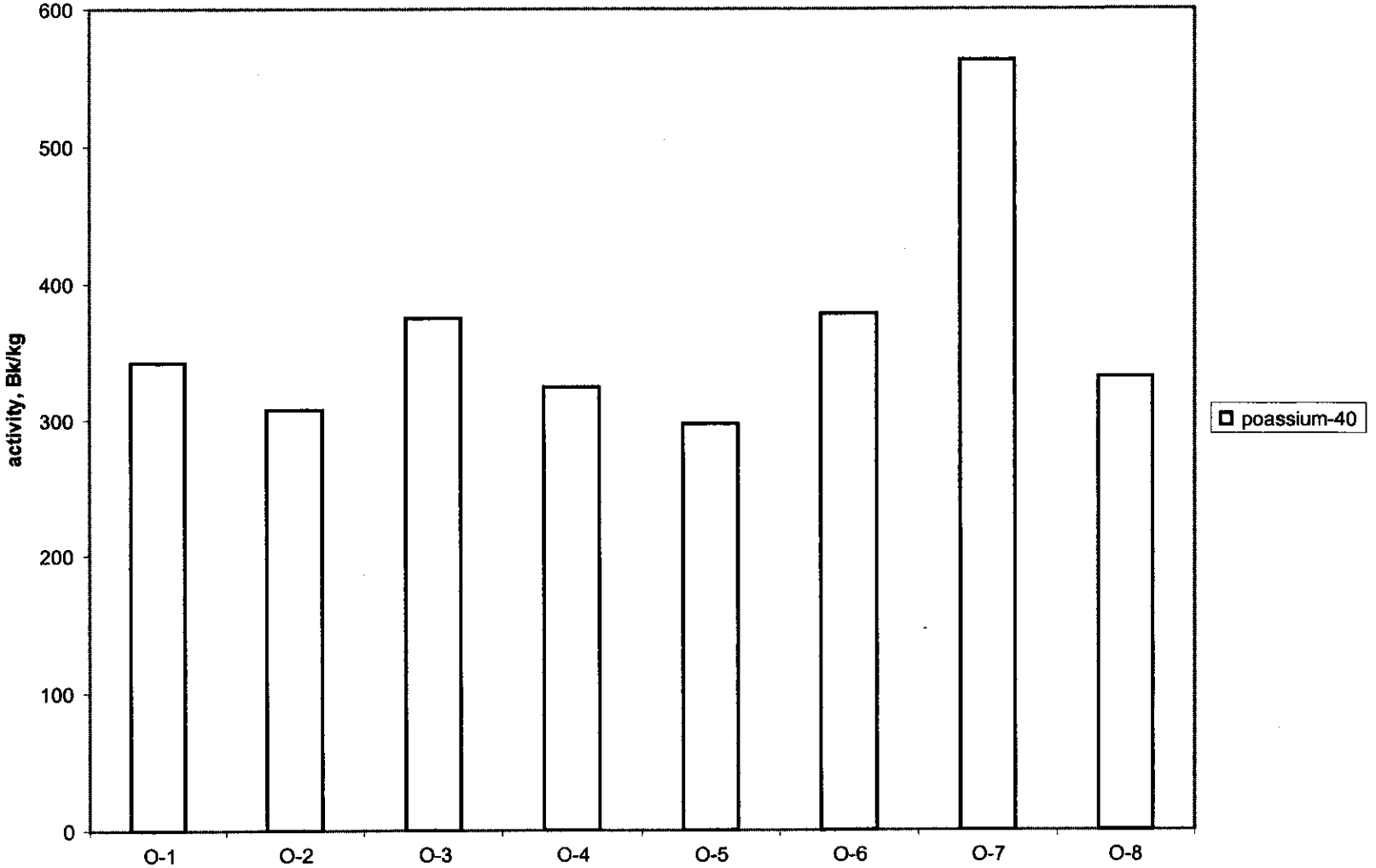

Fig. (3-11) mean activity level of K-40 in olive samples within El Dabaa area

Table (3-11) Concentration of K-40 in Olive samples*)

Sample code	Concentration (Bq/l) K-40
O-1	342.4±4.55
O-2	307.5±2.41
O-3	374.7±3.34
O-4	324.21±9.13
O-5	297.1±9.45
O-6	377.7±11.14
O-7	562.4±14.20
O-8	331.3±10.50

*) K-40 was determined by measuring the gamma-energy lines at 1460KeV. Determinations were carried out through activity measurements by H PGe w ith e fficiency o f 3 0% a nd F WHM o f 1.78 at 1.33 MeV.

<DL= less than detection limit)

Table (3-12) Concentration of K-40 in Flora. samples*)

Sample code	Concentration (Bq/l) K-40
FL-1	34.52±2.44
FL-2	46.8±3.77
FL-3	20.9±1.19
FL-4	48.6±1.44
FL-5	40.6±3.20
FL-6	48.7±4.90
FL-7	39.8±1.39
Fl-8	36.7±1.70

*) K-40 was determined in flora samples by measuring the gamma-energy lines at 1460KeV. Determinations were carried out through activity measurements by HPGe with efficiency of 30% and FWHM of 1.78 at 1.33 MeV.

<DL= less than detection limit)

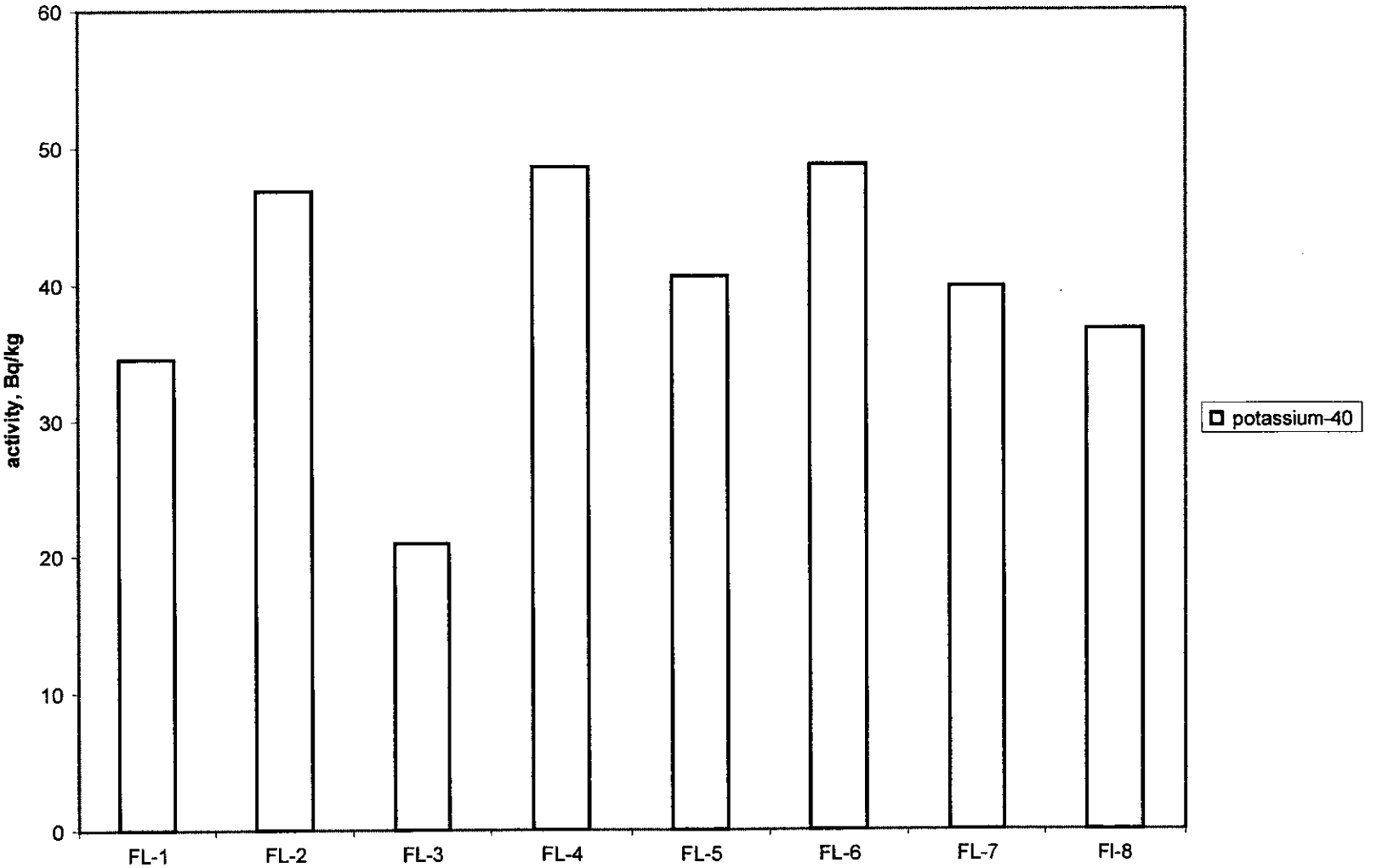

Fig. (3-12) mean activity level of K-40 in flora samples within El Dabaa area

Table (3-13) concentration of K-40 in fish. samples*)

Sample code	Concentration (Bq/Kg) K-40
Fsh-1	455.10±10.1
Fsh-2	149.70±5.1
Fsh-3	336.90±22.1
Fsh-4	354.28±23.3
Fsh-5	490.70±25.9

*) K-40 was determined in fish samples within El Dabaa area by measuring the gamma-energy lines at 1460KeV. Determinations were carried out through activity measurements by HPGe with efficiency of 30% and FWHM of 1.78 at 1.33 MeV.

<DL= less than detection limit)

Table (3-14) Concentration of K-40 in milk samples*)

Sample code	Concentration (Bq/Kg) K-40
M.1	356.00±16.00
M.2	237.80±8.20
M.3	272.00±8.20
M 4	390.50±11.70
M.5	194.67±10.20
M.6	508.7±22.90
M.7	502.60±41.10
M.8	474.8±12.70
M.9	459.30±23.50
M.10	467.20±41.10
M.11	399.40±22.40

*) K-40 was determined in milk samples within El Dabaa area by measuring the gamma-energy lines at 1460KeV. Determinations were carried out through activity measurements by HPGe with efficiency of 30% and FWHM of 1.78 at 1.33 MeV.

<DL= less than detection limit)

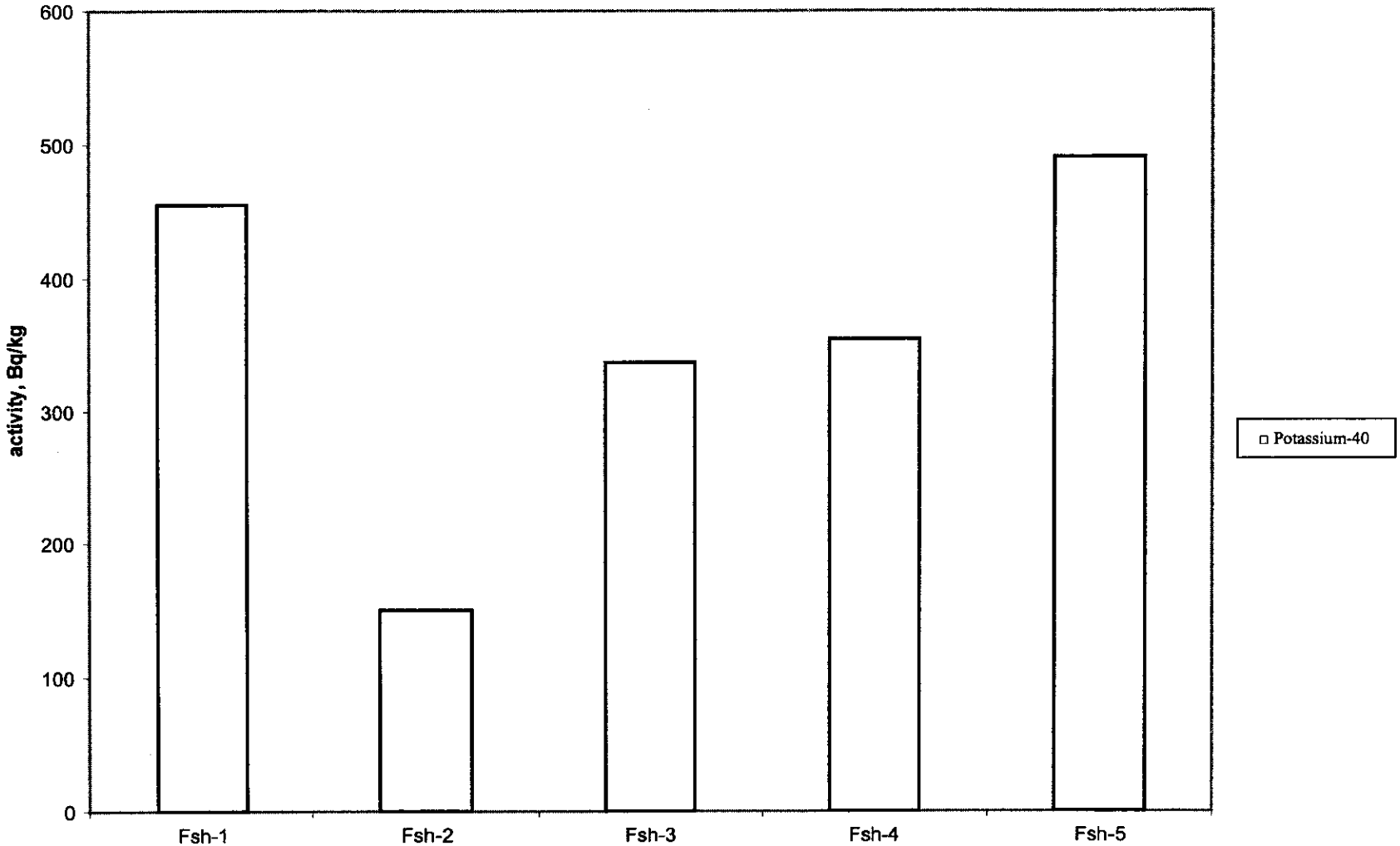

Fig (3-13) mean activityi level of K-40 in fish within El Dabba area

including, gamma-absorbed dose rate, effective dose and radium equivalent activity hazard indices have been estimated.

3.3.1 Absorbed dose rate in air

Radiation in soil is the most important contributor to external terrestrial radiation. Exposure to gamma ray natural radionuclides in free air are controlled by several factors as distribution of radionuclides, moisture and density of ground. The absorbed gamma dose rate in air is a function of radionuclides concentration in the first meter of soil profile (58)
Absorbed dose rate in ($nGyh^{-1}$) in air by external irradiation for a height of 1 meter above ground surface can be evaluated by the following equation (59)

$$D=R_kC_k + R_{Ra}C_{Ra} + R_{Th}C_{Th} \quad (1)$$

where:
D: is absorbed dose rate in nGy/h
C_k, C_{Ra}, C_{Th}: is concentration of K-40, Ra-226 and Th-232 respectively
$R_k R_{Ra} R_{Th}$: are conversion factors, expressed in nGy/hr per Bq/Kg for K-40, Ra-226 and Th-232 respectively. The values are given in Table (3-15)

Table (3-15) conversion factors for gamma ray 1 m above the ground of natural radionuclides)*

radionuclide	Conversion factot (nGy/hr.per Bq/Kg)
^{40}K	0.043
^{238}U	0.427
^{232}Th	0.662

*) ref.(60)

In present study, the absorbed dose rate has been calculated by using equation (1) and knowing the values of dose conversion factors. Table (3-16) clarifies the values of absorbed dose rate which ranges from 15.53 nGy/h at S-18 to 41.51 nGy/h at S-12 with average value of 24 nGy/h. This is in agreement with the data published in UNSCEAR (1988), The value of dose rate in the investigated soil is lower than the average value (55 nGy/h).

3.3.2 Radium equivalent activity

It is considered the most widely used radiation hazard index, also represent the specific activities for Ra-226, Th-232, K-40 in a single quantity, considering associated hazard with them. It can be calculated by the following equation (60)

$$\mathbf{Ra_{eq} = C_{Ra} + 10/7\ C_{Th} + 10/130\ C_k} \quad (2)$$

Where, C_{Ra}, C_{Th} and C_k are the specific activities of Ra-226, Th-232 and K-40 in Bq/Kg, respectively. This formula based on the assumption that 10 Bq/Kg of Ra-226, 7 Bq/Kg of Th-232 and 130 Bq/Kg of K-40 produce the same gamma dose rate (56). The values of radium equivalent for different soil samples are calculated by using equation (2). These values are represented in Table (3-16) which have values ranged from 33.58 to 85.61 Bq/Kg with average value of 50.71 Bq/Kg which is consider lower than the recommended maximum value 370 Bq/Kg (61)

3.3.3 Effective dose

Effective dose for soil samples in area under investigation can be 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 and outdoor occupancy factor 0.2 proposed by UNSCEAR (2000)(62). This calculation takes into account that the people spend 20% of their time outdoors. From Table (3-16), the highest observed annual effective dose are 50.91 μSv at S-2 and the lowest value 19.04 μSv at S-18 with a mean value of 29.43 μSv, this value is lower than the world-wide average annual effective dose which is approximately 70 μSv (UNSCEAR 2000).

Table (3-16) absorbed dose rate & the radium equivalent And effective dose in soil samples within El Dabaa site

Sample code	Absorbed dose (nGy/h)	Radium equivalent (Bq/Kg)	Effective dose $\mu Sv\ y^{-1}$
S-1	18.84	41.35	23.10
S-2	41.51	85.61	50.91
S-3	30.85	64.50	37.83
S-4	25.78	54.65	31.62
S-5	28.41	59.20	34.84
S-6	17.95	39.75	22.01
S-7	24.83	52.45	30.45
S-8	21.50	44.64	26.37
S-9	25.31	52.69	31.04
S-10	34.85	70.69	42.74
S-11	26.01	54.98	31.89
S-12	16.33	36.32	20.03
S-13	24.42	52.65	29.95
S-14	20.24	43.81	24.82
S-15	33.74	70.10	41.37
S-16	20.66	44.88	25.34
S-17	21.72	45.30	26.63
S-18	15.53	33.59	19.04
S-19	23.26	49.03	28.53
S-20	31.25	64.01	38.32
S-21	21.23	45.50	26.04
S-22	20.74	43.43	25.43
S-23	18.88	41.20	23.15
S-24	18.89	39.55	23.17
S-25	17.36	37.95	21.29

3.4 Ambient gamma exposure rates monitoring

The ambient gamma dose rate profile for El-Dabaa site was monitored by three real-time monitors; the "Gamma Tracer". These monitors were placed at three locations at the site. Each monitor includes two Geiger Muller detectors with a sensitivity of 2x0.2 impulses per second with 100 nGy/h. The monitors include a data logger for logging the data at specified time intervals. The logging intervals were adjusted for 1-hour averages. The monitors were calibrated before delivery. The calibration radiation was 662 KeV (Cs-137) and for an energy dependence of ± 30% (45 – 1300 KeV). The calibration stays good for a period of almost 3 years with a calibration error of ± 5%.

The ambient gamma exposure rates were accumulated for approximately 26 consecutive months from three locations at the site. Fig. (3-15) shows the real-time exposure rate profiles at location (meteorological station). An average of exposure rate found to be in the range of 57 nSv/h to 71 nSv/h. This average is in line with the published by UNSCAR (1988) (55). During the whole period there was no record for any spikes that might have taken place. This means that no artificial radiation has hit the site area.

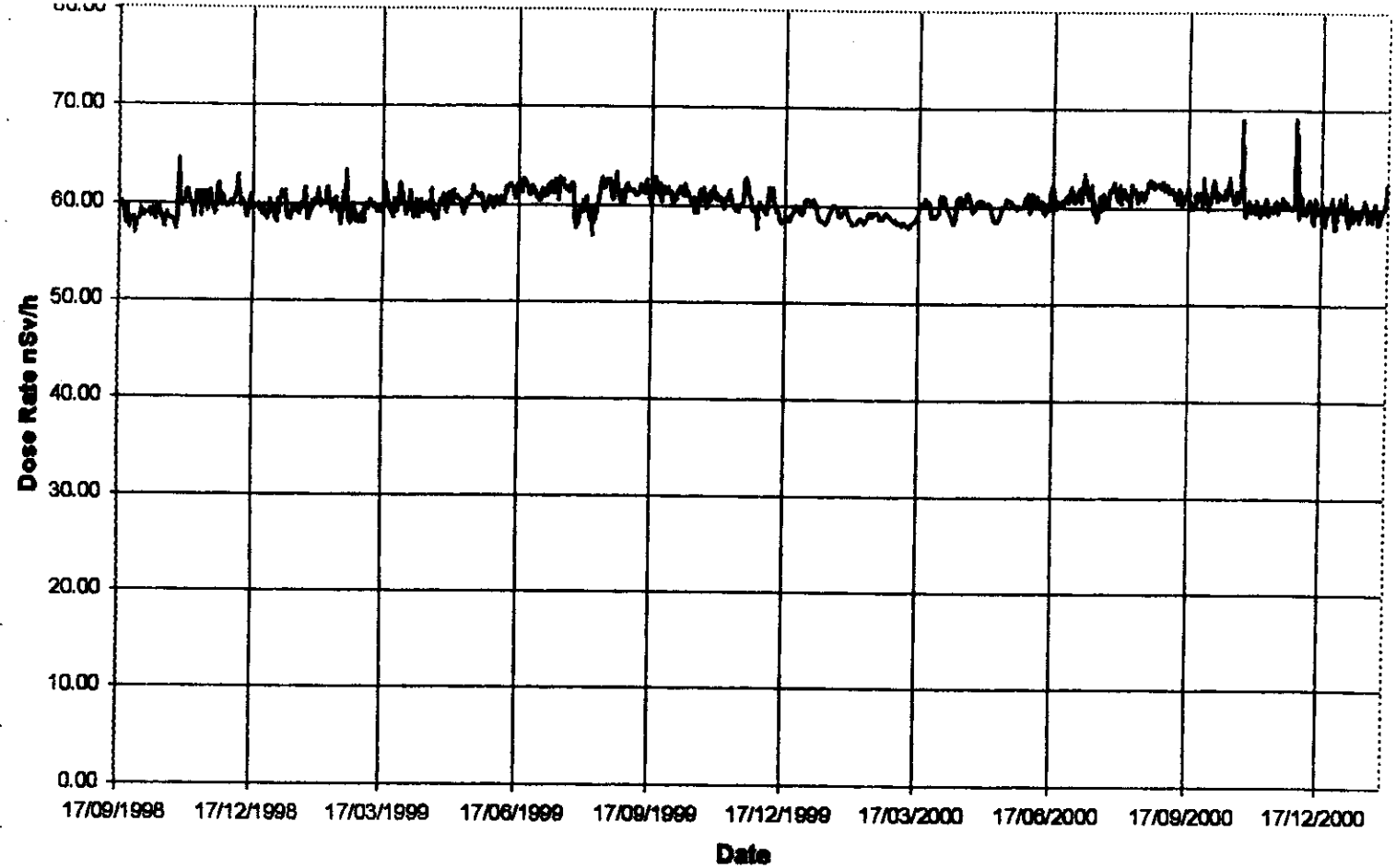

Fig. (3-15) Ambient gamma dose rate for different season located at meteorological tower location at El Dabaa site