CHAPTER ONE

INTRODUCTION

1.1 Background Radiation

Man is exposed to ionizing radiation spontaneously emitted by naturally occurring atomic species like U-238 and Th-232 ever since his existence on the earth. Three types of radiation, alpha, beta and gamma are emitted by different radioactive materials; which differ in their energy and penetrating power.

One was exposed to radiation only from natural sources until recent times, when the growth of nuclear energy has created other sources of exposures, like fallout from weapon tests, radioactive releases from nuclear reactor operations and accidents, exposure due to radioactive waste deposable and industrial, medical and agricultural use of radioisotopes, still, the major contribution to the average annual background radiation arises from natural sources [2].

Exposures from natural sources are due to:

- External source of extraterrestrial origin (cosmic rays).
- Source of terrestrial origin (radioactive nuclides present in earths crust, in atmosphere and in building materials).
- Internal exposure from radio nuclides taken in to the body through ingestion of food materials.
- Indoor inhalation exposures due to radon Rn-222, Thoron Rn-220 and their daughters.

Some of these exposures are relatively constant and uniform to all individuals throughout the world; while others vary depending on the location and due to elevated levels of naturally occurring radioactive substances like uranium U-238 and Thorium Th-232 in specific localized areas.

All exposures except those from the direct cosmic radiation are produced by the radioactivity of natural radionuclide present in environment.

Natural radioactivity present on the earths crust belongs to virgin and modified sources [2].

Virgin sources are cosmologic or primordial and have existed on the earth since primordial time's .Modified sources are from activities like uranium mining, usage of fossil fuel, production of fertilizers or naturally occurring radioactive materials used for building construction. Latter is known are technologically enhanced natural radioactive materials (TENORM). Sources of man-made radiation include nuclear fuel cycle operation, nuclear weapon tests, medical and industrial applications of radionuclides. Extent of exposure to these sources depends on occupation, type of dwelling, location of habitation, life style and level of medical care one receives.

Exposures due to natural radiation are of particular importance because it accounts for the largest contribution (nearly 53 %) to the total collective radiation dose to the world population.

Major contribution of doses from normal background regions arises from the inhalation of Rn-222, Rn-220 and their short lived progeny. Rn-222 and Rn-220 are ubiquitous, and are produced in the course of decay of U-238 and Th-232 series.

Being inert gases, they escape to the atmosphere by diffusion and advection. They emanate from soil and walls of the buildings. Relatively constant exposure to population at location is the distinctive characteristics of this mode of exposure.

Virgin sources due to cosmic ray radiation consist of protons (85 %), alpha particles (14 %) and about 1 % from nuclei of atomic number between 4 and 26. These particles are highly penetrating and have high energy.

Attenuation in the atmosphere decreases the flux of the cosmic rays on the earths surface .As result of this, the cosmic ray exposure becomes double for every 1500 meters above the earth's surface. Cosmic rays are the dominant

source of ionization in the atmosphere from an altitude of 70 km down to around 1 km.

At sea level nearly 80 % of ionization is caused by natural radioactivity, mainly by the emission of alpha particles from airborne radio nuclides. Cosmic rays contribute mainly to the external exposure.

Attenuation of cosmic rays is also caused by buildings, which results in reduction up to 20 % in the cosmic ray exposure indoors. Number of radio nuclides are produced by cosmic ray radiation through the interaction of heavy charged particles coming from outer space, with the atmosphere, which contribute to the natural radiation exposures. Some of the signification cosmologic nuclides thus produced are H, Be, C and Na which contribute mainly to internal exposure through inhalation [2].

Radio nuclide existed on the earths crust since its formation is referred as primordial radio nuclide. They are isotopes of heavy elements. Main primordial nuclides are K-40, Rb-87 and the isotopes of U-238 and Th-232. K-40 is only 0.0118 % of natural potassium but is wide spread, and is important in the food chain. Natural radiation in environment is also caused by the isotopes of U-238 and Th-232 and their long –lived decay chains as well as by K-40 , present in rocks and soil and gives rise to external exposure.

1.2 Radiation Detectors

Ionizing radiation deposits energy in matter by ionization and excitation. Ionization is the removal of electrons from atoms or molecules [1] .An atom or molecules stripped of an electron has onest positive charge and is action. In many gases, the free electrons become attached to uncharged atoms or molecules .From negatively charged anions an ion pair consists of cation and its associated free electron and anion. Excitation is the elevation of electrons to excited states in atoms, molecules or crystal .Excitation

And ionization may produce chemical changes or emission of visible light .Most energy deposited by ionizing radiation converted to heat.

1.3 Type of Detector

Radiation detectors may be classified by their detection method. Gas filled detector consists of volume of gas between two electrons. The interaction of ionizing radiation with certain materials produced ultraviolet and or visible light the materials are called scintillation.

Semiconductor detectors are especially pure crystals of silicon , germanium, or other semiconductor materials to which trace amounts of impurity atoms have been added so that they acts as diodes . When used to detect radiation, voltage is applied in the direction in which little current flows. When an interaction occurs in the crystal, electrons are excited state, allowing momentary electrical current to flow through device.

Detectors may also be classified by the type of information produced. Detectors, such as Geiger Mueller (GM) detectors that indicate the number interaction occurring in the detectors are called counters. Detectors that yield information about the energy distribution of the incident radiation. Such as NaI scintillation detectors, are called spectrometers. Detectors that indicate the net amount of energy deposited in the detectors by multiple interactions are called dosimeters [1].

1.4 Soil Radioactivity

The great interest expressed worldwide for the study of naturally occurring radiation and environmental radioactivity has led to the interest of extensive surveys in many countries [4].

Natural environmental radioactivity arises mainly from primordial radio nuclides, such as K-40, and the radio nuclides from Th-232 and U-238 series, which occur at trace levels in all ground formation [3].

Measurement of natural radioactivity in soil is very important to determine the amount of change of the natural background activity with time as result of any radioactive release.

Natural environmental radioactivity and the associated external exposure due to gamma radiation depend primarily on the geological and geographical

conditions, and appear at different levels in the soils of each region in the world. The specific levels are related to the types of rocks, such as granite, and lower levels with sedimentary rocks. There are exception; however as some shale, s phosphate rocks have relatively high contents of radionuclides.

Many areas in the world such as, India, Iran, Japan, Australia, Brazil, China etc., possess high levels of natural radiation. In the recent years, studies on the high background radiation areas in the world have been of prime importance for risk estimation due to long term low –level whole body exposures to the public. The high radiation levels are due to presence of large quantities of naturally occurring radioactive minerals in the rocks, soil sediments [3].

According to the United Nation Scientific Committee on the Effects of Atomic Radiation , (UNSCEAR , 1993), the world mean dose from natural radiation sources of normal areas is estimated to be 2.4 msvy-1, while that for all man-made sources, including medical exposure, is about 0.8 msvy-1. Thus 70 % of the radiation dose received by human population is from natural radiation sources [4].

1.5 Study Problem

* In Port Sudan city, the main port of Sudan, data on the levels of natural radioactivity in soils is absent.

*There is increasing incidence of cancer in Port Sudan which necessitate more investigation to be carried out for the possible causes of these cancers.

1.6 Aim of Study

- Measure the natural radioactivity levels in soil samples around different location in Port Sudan city.
- Measure the absorbed dose and annual effective dose were also evaluated and compared to the world average values.

1.7 Thesis Lay Out

The thesis consists of the four chapters. Chapter one is the Introduction, Chapter two is the theoretical background, Chapter three consist of method, materials and Chapter four Results and Discussion.

CHAPTER TWO

THEORETICAL BACKGROUND AND LITERATURE REVIEW

2.1 Dosimeter Principles, Quantities and Unit

2.1.1 Radiation Exposure and Dose

Because of their importance in personnel protection at radiation producing facilities and in the medical applications of radiation, the concepts of radiation exposure and dose play prominent roles in radiation measurements. In the following sections, we introduce the fundamental concepts that underlie the quantities and units of importance in this area.

Precise definitions of quantities related to radiation protection are continually evolving, and the reader is referred to publications of the International Commission on Radiological Units and Measurements (ICRU), the International Commission on Radiological Protection (ICRP), and the U.S. National Commission on Radiation Protection (NCRP) for up-to –date information [5].

2.1.2 Dose Monitoring

Personal real-time dose alarms and long term (film badges) are available if engineering controls and access restriction cannot guarantee dose controls [6].

2.1.3 Absorbed Dose

The absorbed dose is defined as the mean energy ε imparted by ionizing radiation to matter of mass m in finite volume V by:

$D = d\varepsilon/dm$

The energy imparted ε is the sum of all the energy entering the volume of interest minus all the energy leaving the volume, taking into account any mass-energy conversion within the volume.

The unit of absorbed dose is joule per kilogram (J/kg) .The name for the unit of absorbed dose is the gray (Gy) [1].

2.1.4 Equivalent Dose H (T)

The biological detriment (harm) to an organ depends not only on the physical average dose received by the organ but also on the pattern of the dose distribution that results from the radiation type and energy. For the same dose to the organ, neutron radiation will cause greater harm compared with grays or electrons. This is because the ionization events produced by neutron radiation will be much more closely spaced (densely ionizing radiations) and so there is higher probability of irreversible damage to the chromosomes and less chance of tissue repair.

Consequently, the organ dose is multiplied by radiation weighting factor W(R) to account for the effectiveness of the given radiation in inducing health effects ; the resulting quantity is called the equivalent dose H(T) .

$H(T) = W(R)\, D(T, R)$

Where:

D (T, R) is the absorbed dose delivered by radiation type R averaged over tissue or organ T. W(R) is the radiation weighting factor for radiation type R. For X rays, γ rays and electrons W(R) =1 .The SI unit of equivalent dose is J/Kg and its name is the sever (Vs.); the old unit is the ram and the relationship between the two units is 1 Vs. = 100 ram [1].

2.1.5 Effective Dose

The relationship between the probability of stochastic effects and equivalent dose is also found to depend on the organ or tissue irradiated. This implies that for the same equivalent dose the detriments from the exposure of different organs or tissues are different. To take account of these differences, tissue weighting factors are needed. Tissue weighting factors W (T) should represent the relative contribution of an organ or tissue to the total detriment due to the effects resulting from uniform irradiation of the whole body .For low doses, individual organ or tissue detriments can be treated as additive and the total detriment to the whole body is the summation of individual detriments. The relative contribution to the total detriment is therefore given

by the quotient between the individual detriments and the total detriment resulting from uniform irradiation of the whole body. Since the sum of relative contributions is normalized to unity, $\Sigma w(T) = 1$ .The effective dose E is defined as the summation of tissue equivalent doses, each multiplied by the appropriate tissue weighting factor W(T) ,to indicate the combination of different doses to several different tissues in away that correlates well with all stochastic effects combined [1] .

$E = \Sigma W(T) H(T)$

2.2 Reviw of Previous Studies

- **Nooreldin et al**, [7] investigated the natural radioactivity levels in soil samples from North kordofan state, Sudan. The radioactivity concentration of U-238, Th-232, k-40 and Cs-137 have been determined using γ – ray spectrometry NaI (TI) detector. Moreover, the absorbed dose rates and annual effective dose were calculated. The average value of U-238 , Th-232 , k-40 and Cs-137 were found to be 22 , 83 , 25 , 11 , 284 , 31 and 0.28 Bg / kg respectively . The obtained results were found to be lower than UNSEAR reported data. The absorbed dose rates and annual effective dose were determined and found to be in range of 25 to 29.61 nG / h and 30 to 41 sv / y respectively. The authors reported that, the overall annual effective dose lower than allowable limit set by ICRP (1sv / y).
- **Furthermore et al,** [9] in the current work have been measured with view to determining their radioactivity concentration. These provided baseline radiological map across the entire country of Kuwait. The measured activity concentrations range 6↔32 Bq / kg and 4↔27 Bq / kg for U-238 (Ra-226) and Th-232 (Ac-228) respectively. The evaluated activity concentrations of U-238, Th-232 and k-40 across all of the soil samples produce mean values of 18, 15 and 385 Bq / kg respectively. Clear correlation is also absorbed between U-238 and Th-232 chain activity concentrations. The mean external dose –rate and

radium equivalent values are 33.0 ↔ 2.5 nG / hr and 68.5↔5.0 Bq /kg respectively. The internal and internal hazard indices are 0.23 ↔0.02 and 0.19 ↔ 0.01 respectively. The result of the activity concentrations of U-238 , Th-232 and k-40 fall below the world wide average values of 35 , 40 and 400 Bq / kg (UNSCEAR , 200) .

- **Furthermore et al,** [10] the average activity concentrations of Soil samples for the Ardahan province in Turkey were found to be 29.9 ↔ 6.5, 7 ↔ 6.9, 435 ↔ 239 and 15.5 ↔ 0.8 Bq / kg for U-238, Th-232, K-40 and Cs-137 respectively. The concentrations of Th-232 and k-40 in soil sample of Ardahan province are higher than world wide mean values but the concentration of U-238 is slightly lower than the world wide mean values. As can be seen from our analysis there is good correlation between the altitude and the activity concentrations of soil samples for the studied area. The results obtained have shown that annual effective dose rate due to natural radioactivity of samples is very much comparable with recommended world value and also with values reported in literature. The obtained data from this study can be used as baseline data for producing radiological map of the studied area and determining the effects of radioactive contamination in the future.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Sample Collection and Preparation

Samples were collected from different location around Red Sea costal in Port Sudan city. Port Sudan location is consisting of three dissectors (middle, eastern and southern). The eastern dissector samples are (Salabona , Althwra , Algadesia , Hay Alkaleeg , Deem Alnoor) represented (A1, A2, A3, A4, A5) respectively. The middle dissector samples are (Seka Hadeed , Shager Squire8 ,Shager Squire9 , Shager Alnamozagia , Aleskan , Salalab) represented (B1, B2, B3, B4, B5, B6) respectively. The southern dissector samples are (Hay Almetar , Alganayn , Transeet) represented (C1, C2, C3) respectively. All samples were preferred to be undisturbed and non-eroded without any influenceHadeed of man-made structures to ensure that samples were representatives of the sites from where they were taken .From each site, 4 – 6 soil samples were collected and the depth 10 cm .

In this way, total of 14 soil samples were collected from all sites. Samples were kept for period of 1 month to make sure the samples attained the radioactive equilibrium between Ra-226 with its decay products in the uranium series [7].

3.2 Gamma Spectroscopic Measurement

For the measurement 0f activity concentrations of naturally occurring radionuclides of U-238, Th-232 and K-40 in soil samples, NaI TI detector based gamma ray spectrometer with relative efficiency of 35 %was employed.

NaI detector was coupled with ICX multichannel analyzer (MCA). The resolution (FWHM) of the spectrometry system was (0.7% to 14 % at 1332 Kev) gamma-ray line of Co-60.

Spectrum of every sample was collected for 14.600 seconds (3h). Spectrum analysis was performed with computer software and activity concentrations of 3 natural radionuclide were determined. To reduce the background effect, the

detector was shielded in 10 cm wall lead covering lined with 2 mm copper and 2 mm cadmium foils.

The reference material (RADIOACTIVE MIXED NUCLIDE MW 652) obtained from International Atomic Energy Agency (IAEA) have been used for calibration of the spectrometer. The system was calibrated for energy and relative efficiency on regular basis. The activity concentration of Th-232 was determined by measuring 238 Kev peak from PB-212, 911 Kev peak from AC-228 and 967 Kev peak from Ac-228. The activity concentration of K-40 was determined using single peak of 1460 Kev.

The activity concentration of U-238 determined by measuring 609 Kev from Bi-214, 352 Kev from Pb-214 and 295 Kev from pb-214.

The gamma background level at the laboratory site was determined with an empty plastic container washed with dilute HCI and distilled water [8].

The background was measured under the same conditions of the measurement of the samples.

It was later subtracted from the measured gamma-ray spectra of each sample. Following the spectrum analysis, count rate for each detected photo peak and activity per mass unit for each of the detected radionuclides was calculated. The activity concentration (in Bq / kg), A (Ei), of radionuclide i and for peak at energy E, is given by: $A(Ei) = C(Ei) / C(eff). I(\gamma). m. t$ (3.1)

Where : C(Ei) is the total count of peak at energy E , C(eff) is the detection efficiency at energy E , t is the counting time , I(γ) is the number of gammas per disintegration of the radionuclide i for transition at energy E , and m is the mass in kg of the measured sample.

The activity concentration of each of the 3 radio nuclides was finally measured in Bq /kg.

The absorbed dose rate (nGy/h) ,D was calculated from U-238, Th-232 and k-40 activity concentration using different dose rate conversion factors (DRCFs) as given in Table (3.1).

The absorbed dose rate was computed using the following equation:

$D = A * DRCFs$ (3.2)

Figure (3.1) NaI (TL) detector based gamma ray Spectrometer

Where*:*

D: absorbed dose rate.

A: radioactivity concentration in Bq /kg.

DRCFs: dose rate conversion factors (nGy / h per Bq /kg) as given in Table (3.1)

3.3 Estimation of Gamma Radiation Dose (D)

The gamma radiation population doses of those living in the area are given as:

$D = 0.427\ Cu + 0.662\ CTh + 0.043\ Ck$

Where:

D is the dose rate in nGy / h and Cu, CTh and Ck are the concentrations of Uranium, Thorium and Potassium respectively.

The absorbed dose rate in air was converted into annual effective dose (μ sv / y) using the following conversion equation:

$H(\mu sv/y)=D(nGy/h)\gamma*24h*365.25\,d*0.2*0.7(svGy/y)*10^{-3}$

(3.3)

Where**:**

0.7 svG / y: is the conversion coefficient from absorbed dose in air to effective dose received by an individual, and 0.2 for the out door occupancy factor [8].

Table (3.1) Dose rate conversion factors for some radionuclide used for calculation of absorbed dose (n G/h)

Nuclide	MC	MCNP	GEANT	UNSCEAR
U-238 series				
Pb-214	0.04413	0.0415	0.0434	0.462
B-214	0.34156	0.3385	0.3555	0.462
Total	0.38668	0.3809	0.3999	
Th-232 series				
Pb-212	0.0193	0.017	0.0192	0.604
Total	0.5239	0.5168	0.5437	0.604
K-40	0.381	0.0378	0.03995	0.0417

CHPTER FOUR

RESULTS AND DISCUSSION

4.1 Results and Discussion

The results of the measurements of natural radio nuclide (Ra-226, Th-232 and K-40) concentrations and also measurements absorbed dose and annual effective dose from three dissections (eastern, middle and southern) in the 15 soil samples collected from studied areas.

Table (4.1) shows the radioactivity concentrations in Bq / kg of Ra-226, Th-232 and K-40, absorbed dose rate (ADR) and annual effective dose (AED) measured in the soil samples from eastern dissector. From the table we can be observe that , the level of Ra-226 , Th-232 and k-40 ranged from (10.80 to 12.60) , (10.53 to 33.70) and (216.03 to 540.08) Bq / kg with average(18.814) , (25.696) and (424.862) respectively . The absorbed dose rate of Ra-226, Th-232 and K-40 ranged of (20.358171 to 52.196986) with average value (41. 9278119).

The annual effective dose of Ra-226, Th-232 and K-40 ranged from (24.967260 to 64.014383) with average value (51.420267).

Figures (4.1.a) ,(4.1.b) and (4.1.c) shows the activity concentrations in Bq/kg of Ra-226 , Th232 and K-40 respectively in soil samples from eastern dissector in Port Sudan location , Red Sea .

From figures (4.1.a), (4.1.b) and (4.1.c) it's clear that, the regions of A2, A4 showed the highest level Ra-226 (21.60) Bq/kg. The highest level of Th-232in regions A4, A5 (33.70) Bq/kg and high level of K-40 in region A5 (540.08) Bq/kg. The high activity observed in these regions be due to their geological nature.

Table (4.1) Radioactivity concentrations Ra-226, Th-232 and K-40 measured in the soil samples, absorbed dose rate (ADR) and annual effective dose rate (AED) at present study from eastern dissector.

Sample	Ra-226 Bq/kg	Th-232 Bq/kg	K-40 Bq/kg	AD(nGy/h)	AED µsv/y
A1	10.80	10.53	216.03	20.358171	24.967260
A2	21.60	23.17	432.06	41.988472	51.494662
A3	19.89	27.38	468.07	45.245219	55.488736
A4	21.60	33.70	468.07	49.850209	61.136296
A5	20.18	33.70	540.08	52.196986	64.014383
Average	18.814	25.70	424.862	41.9278114	51.420267
Min	10.80	10.53	216.03	20.358171	24.967260
Max	21.60	33.70	540.08	52.196986	64.014383

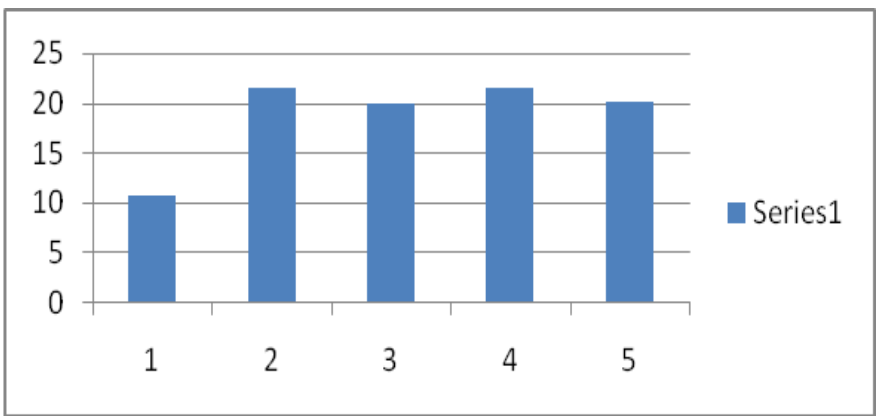

Figure (4 .1. a) Activity distribution of Ra-226 in soil samples

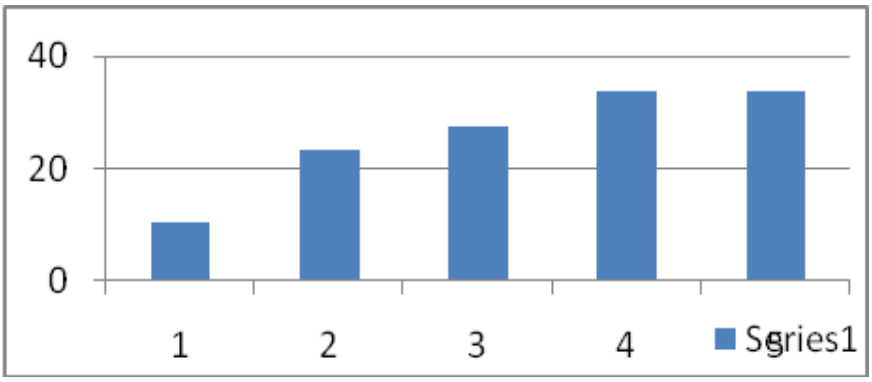

Figure (4.1.b) Activity distribution of Th-232 in soil samples

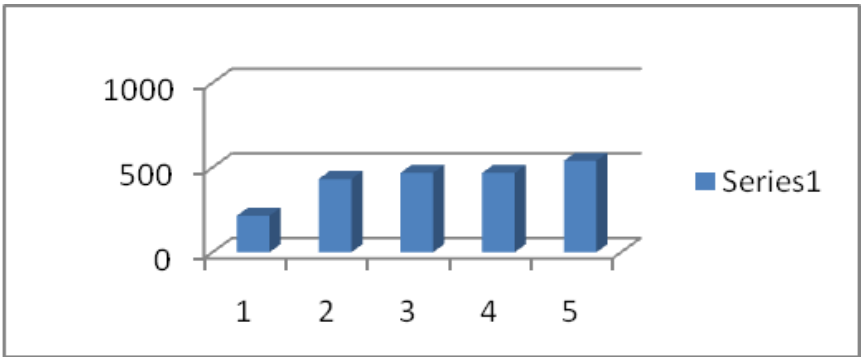

Figure (4.1.c) Activity distribution of K-40 in soil samples

Table (4.2) shows radioactivity concentrations in Bq / kg, absorbed dose rate (ADR) and annual effective dose (AED) of Ra-226, Th-232 and K-40 in the

soil samples from middle dissector. From the table we can be observe that, the level of Ra-226, Th-232 and K-40 ranged from (23.02 to 30.98), (25.27 to 50.55)

And (432.07 to 612.09) Bq / kg with average value (27.52), (35.45) and (522.08) respectively. The absorbed dose ranged from (48.077579 to 68.865186) with average value (55.897880).

The annual effective dose ranged from (58.962342 to 84.456264) with average value (68.55316).

Figures (4.2.a) , (4.2.b) and (4.2.c) shows the activity concentrations in Bq/kg of Ra-226 , Th-232 and K-40 respectively in soil samples from middle dissector in Port Sudan location , Red Sea .

From figures (4.2.a), (4.2.b) and (4.2.c) it's clear that, the region of B3 showed the highest level of Ra-226 (32.40) Bq/kg. The high level of Th-232 was observed in B5 (50.55) Bq/kg .the high level of K-40 in B3 (612.09) bq/kg.

Table (4.2) Radioactivity concentrations Ra-226, Th-232 and K-40 measured in the soil samples, absorbed dose rate (ADR) and annual effective dose rate (AED) at present study from middle dissector

Samples	Ra-226 Bq/kg	Th-232 Bq/kg	K-40 Bq/kg	AD (nGy/h)	AED µsv/y
B1	24.72	29.49	540.08	51.756246	63.473860
B2	23.02	37.91	504.07	54.552599	66.903307
B3	32.40	25.27	612.09	55.753723	68.376365
B4	24.72	42.12	468.07	56.381949	69.146822
B5	30.98	50.55	576.08	68.865186	84.456264
B6	29.27	27.38	432.07	48.077579	58.962342
Average	27.52	35.45	522.08	55.897880	68.553127
Min	23.02	25.27	432.07	48.077579	58.962342
Max	30.98	50.55	612.09	68.865186	84.456264

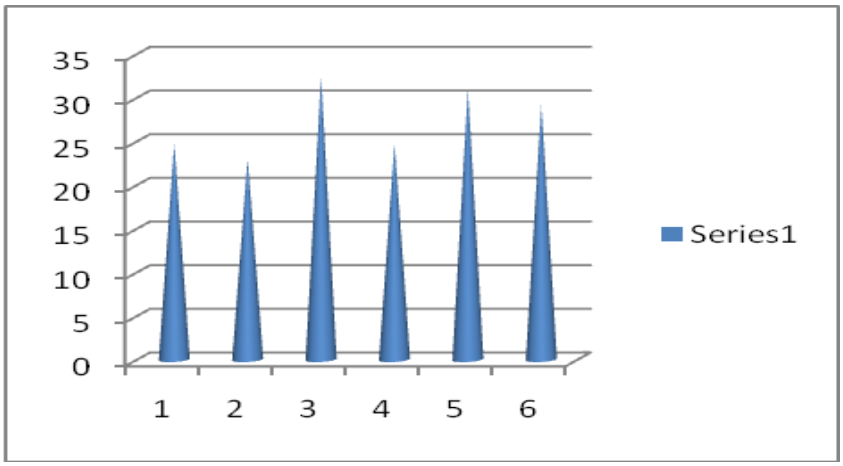

Figure (4.2.a) Activity distribution of Ra-226 in soil samples

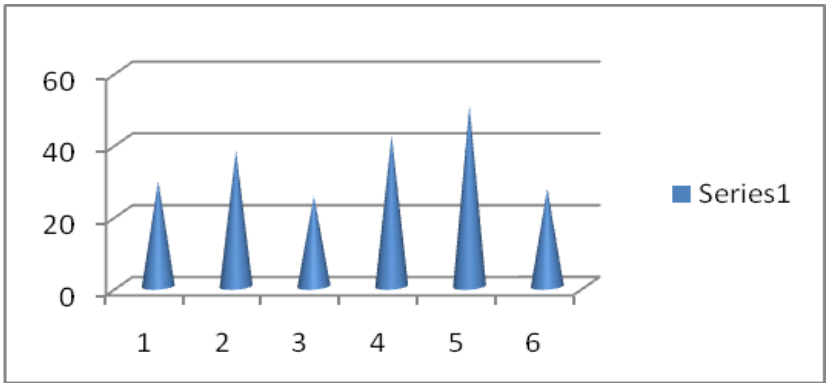

Figure (4.2.b) Activity distribution of Th-232 in soil samples

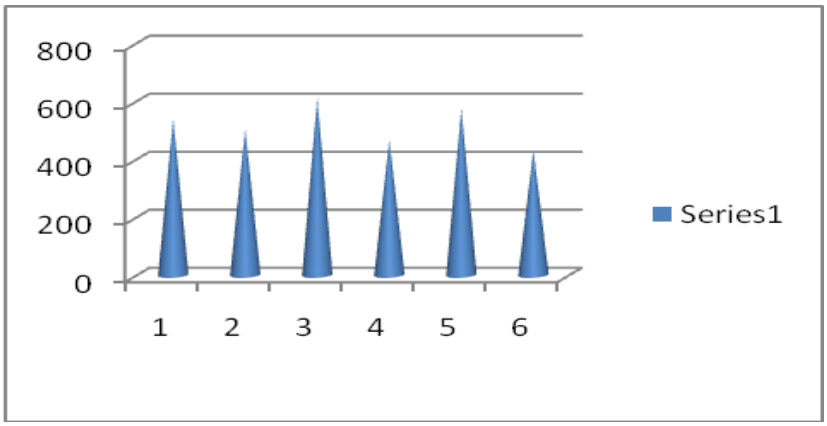

Figure (4.2.c) Activity distribution of K-40 in soil samples

Table (4.3) shows radioactivity concentrations , absorbed dose rate and annual effective dose of Ra-226 ,Th-232 and K-40 in the soil samples from southern dissector .From the table we can be observe that , the level of Ra-226 , Th-232 and K-40 ranged from (21.88 to 27.56) , (35.81 to 46.34) and (504.07 to 648.1) with average values (25.29) , (42.13) and (588.09) .

The absorbed dose ranged from (57.261953 to 67.22579) with average value (61.652471). The annual effective dose ranged from (70.226059 to 82.445709) with average value (75.61059).

Figures (4.3.a) , (4.3.b) and (4.3.c) shows the activity concentrations in Bq/kg of Ra-226 , Th-232 and k-40 respectively in soil samples from southern dissector in Port Sudan location .

From figures (4.3.a), (4.3.b) and (4.3.c) the highest level of Ra-226 in region C2 (27.56) Bq/kg. In addition the highest level of Th-232 and K-40 was observed in C3 (46.34) Bq/kg, (648.1) Bq/kg respectively.

Table (4.3) Radioactivity concentrations Ra-226, Th-232 and K-40 measured in the soil samples, absorbed dose rate (ADR) and annual effective dose rate (AED) at present study from southern dissector.

Samples	Ra-226 Bq/kg	Th-232 Bq/kg	K-40 Bq/kg	AD (nGy/h)	AED μSv/y
C1	21.88	35.81	612.09	57.261953	70.226059
C2	27.56	44.23	504.07	60.469669	74.160002
C3	26.43	46.34	648.1	67.22579	82.445709
Average	25.29	42.13	588.09	61.652471	75.61059
Min	21.88	35.81	504.07	57.261953	70.226059
Max	27.56	46.34	648.1	67.22579	82.445709

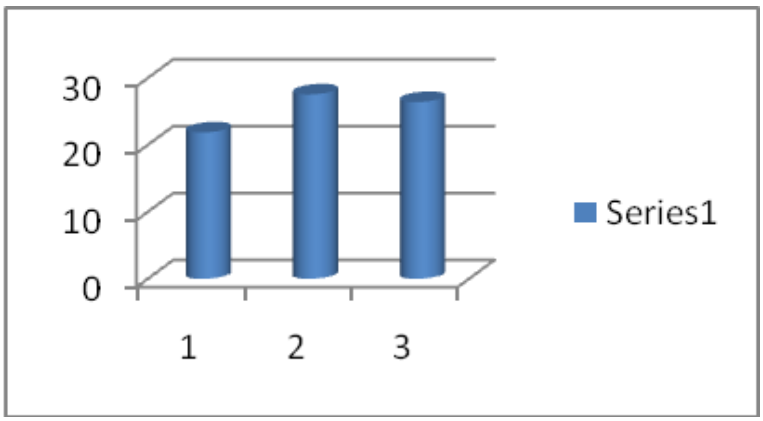

Figure (4.3.a) Activity distribution of Ra-226 in soil samples

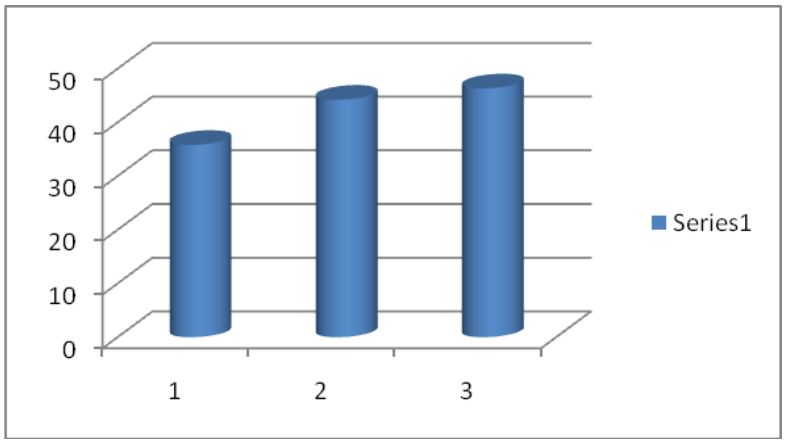

Figure (4.3.b) Activity distribution of Th-232 in soil samples

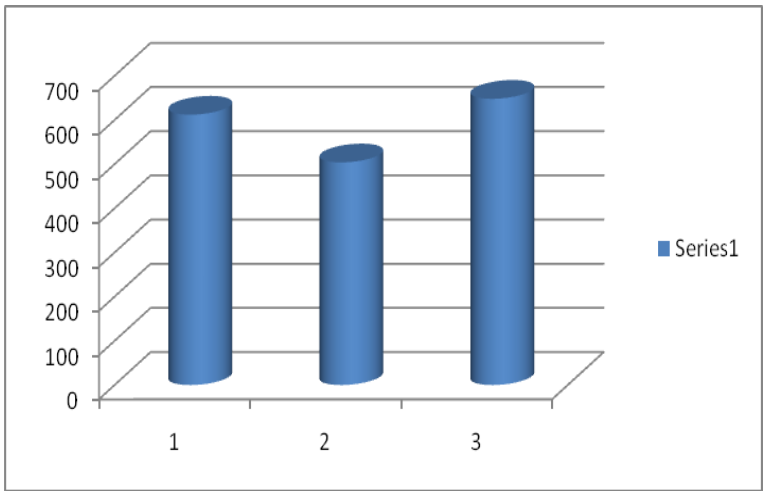

Figure (4.3.c) Activity distribution of K-40 in soil samples

The average activity concentrations of Ra-226 for middle dissection is higher than the average activity concentration eastern and southern.

The average activity concentrations of Th-232 and K-40 for southern are higher than the average activity concentrations of eastern and middle dissector. The relatively high values of K-40 may be result of its abundance in the earth crust .in addition the heavy utilization of potassium having manure in the area close to the sampling areas may be conduce to the excessive values of K-40 activity .

The absorbed dose rates in air for the soil samples in three dissection (eastern, middle and southern) are calculated.

The values ranged from (20.358171 to 52.196986)with average (41.9278114) , (48.077579 to 68.865186) with average (55.897880) and (57.261953 to 67.22579) with average (61 .652471) respectively . We observed the average of absorbed dose in air in southern dissector is high than them (eastern, middle).

The annual effective out door dose rates estimated for soil samples in three dissection (eastern, middle and southern) ranged (24.967260 to 64.014383) with average (51.420267)

, (58.962342 to 86.456264) with average (68.55326) and (70.226059 to 82.445709) with average (75.61059) respectively . Our results for average annual effective dose rate in the range of three dissections we founded the average of southern is higher than others.

4.2 Conclusion

In this study may provide radioactivity levels of naturally occurring radio nuclides of Ra-226, Th-232 and K-40 in soil samples from the three dissections. Found that, measured average activity concentrations of Ra-226, Th-232 and K-40 in soil from the three dissections within the world wide recommended values. The results obtained have shown that the annual effective dose rate due natural radioactivity of samples. The obtained data from this study can be used as baseline data for producing radiological

elements of the studied area and determining the effects of radioactive contamination in the future.

4.3 Recommendations

- This study may be used to collaborate in the development of reference levels of natural radioactivity in Port Sudan location.
- Determine background radiation to evaluate the health hazard.
- Needed investigations to study the natural radioactivity in all the area of Red Sea locations.

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