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RESEARCH ARTICLE

A COMPARATIVE STUDY OF TERRESTRIAL GAMMA DOSE RATE IN AIR MEASURED BY DIFFERENT PORTABLE SURVEY METERS AROUND THE PETROLEUM-PRODUCING AREAS OF THE-QAR PROVINCE, IRAQ

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Abstract

Two different survey-meters are used to measure the gamma dose rate inthe area of oil and gas production of the Thi-Qar province, southeast of Iraq. The obtained results are compared with those previously obtained by the gamma spectroscopic analysis of collected soil samples from the same study regions.The obtained dose rate by using RadEye (PRD) survey-meter was ranged (0.06-0.19)nGyh^{-1}, while those by using Ludlum survey meter were ranged(10.23-33.48) nGyh^{-1}. Gamma spectroscopic analysis of the collected samples showed that the calculated dose rate is ranged(14.77-38.78) nGyh^{-1}which is higher than those obtained by RadEye (PRD) survey-meter and comparable with those obtained byLudlum survey meter. Using the gamma survey meters to determine the dose rates inside these regions cannot be trustedand the long methodology of the gamma spectroscopic analysis of the collected samples is highly required.

Introduction:-

With the increase in global progress in all levels, this progress has had a tax payable in all fields, including what humanity pays in the field of development in the costs related to and associated with the field of radiation and exposure to it and with the rapid increase in exposure levels increased, especially in the industrial and medical fields in addition to Natural sources.

Humanity is exposed to radiation through cosmic and terrestrial sources. Terrestrial radiation is produced by radionuclides and dispersed in varying quantities in the atmosphere, in water, soil, rocks, in building materials and in some foods, where they are transmitted to humans through inhalation or the food chain. All humanity on Earth is exposed to different levels of ionizing radiation. The great progress made in the demand for petroleum products has led to the speed of progress and the increase of workers in this field, but each progress has a tax, including exposure to radiation sources in the oil and gas industry. The processes accompanying the extraction of oil and gas from inside the ground are accompanied by some formation water and some solid materials, dissolved in the formation water and some solid materials. These materials are deposited on all surfaces of the equipment used in these processes, As well as the water injection process associated with the extraction processes to maintain the pressure leads to mixing the formation water with the injection water.

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The activity concentrations of (Radium-226, Radium-228) and decay products in deposits and sludges may vary from normal levels in soils and rocks (less than 0.1 Bq/g) to more than (1000) Bqg^{-1} [1]. However, the activity concentration is still low by comparison with the specific activity of most man-made radioactive sources.

Naturally occurring radioactive materials (NORM) can be of huge contamination potential when brought to earth's crust during the recovery processes of crude oil and gas. This can cause the contamination of food and water to be consumed by humans. NORM contained in oil gas mixture with water accumulates in scrapings, sludge, and scale. NORM accompanied with the production of oil and gas is called "Technologically Enhanced Natural Occurring Radioactive Materials" [2]. TENORMs in the oil and gas industry may produce more noteworthy radioactivity levels, which in the end speaks to potential radiological and health dangers [3,4].The average radiation dose received due to these radionuclides sometimes exceeds the exclusion level suggested by the IAEA's safety standards [5]. Geothermal industry, TENORM can be found in different phases depending on its solubility and its ability to precipitate as a mineral phase. These radionuclides can stay trapped in the rock matrix within the reservoir, precipitate along the pipes of the industrial installations, be present in residues, or soluble in the produced fluids (oil, gas, water) [6].

The aim of this study is to investigate how the measured dose rate obtained by different types of survey meter can be trusted to the extent that we can dispensable the long methodology of the gamma spectroscopic analysis of the collected samples.

Materials and Methods:-

Study area:

Thi-Qar provinceis located at the southeast of Iraq the area of the province is 12,900 km^2 and shares internal borders with the provinces of Missan,Basrah, Wassit, Muthanna, and Qadissiya. Al-Nasiriyah is the capital of Thi-Qar province,the distance between it and the capital, Baghdad, is 362 km.The province contains many different oil sites that will be outlined. We have selected four areas for oil and gas production, namely Nasiriyah oil field (NOF), Al-Gharraf field (AGOF), Subba oil field (SOF) and Thi-Qar refinery (TQR).

Dose rate measurementusingRadEye(PRD) survey meter:

Rad Eye. model (PRD) is shown in Fig. 1. The external exposure dose rateweremeasured in the four regions usingRad Eye. It was supplied with highly sensitive NaI scintillation detector (2x2 inches) which is operational with a mini photo- multiplier to permit the detection of very low radiation levels. Gamma ray spectroscopy systems that adopt NaI as a detector use on-site measurement systems at a certain temperature by transferring electrons resulting from the radiation reaction and converting them to optical electrons indirectly to generate electrical impulses. The measuring range is 10 μSv/h -250 μSv/h count display up to 800kcps, depending on calibration and photon energyand accurately (85%).

Fig. (1):- Rad Eye device survey meter.

Gamma absorbed dose rates usingLudlumsurvey meter:
The absorbed dose rates for ambient gamma were measured in allsampling sites in the four regions using Ludlum model (2241-2). The Ludlum device is shown in fig (2). This device can measure both Beta and Gamma absorbed dose rates in air. This device consists of thallium - activated sodium iodide crystal. This device was checked out using ^{137}Cs standard source. It was supplied Geiger-Mueller(G-M) (H=1.8 * W=2.7 * L=10.70)it consists of a cylindrical cathode formed in the form of a granite layer on the inner house of a glass envelope and also from a fine tungsten wire anode that runs along the tube in the axisThis is done by means of filling (argon or neon) with one of the inert gases, using a partial pressure of approximately 100 Torr, and using (halogens or organic vapors) for cooling at a pressure of 10 Torr.

Fig. (2):- Ludlum survey meter device.

Results and Discussion:-

External exposure using RadEye (PRD):
The external exposure, minimum, maximum, average, Geo mean (GM), and standard deviation (GSD) for different petroleum area in thi-Qar province measured using portable dose survey (PRD) meter, are presented in Table 1 all measuring within the word average range [7].

Gamma absorbed dose rates and annual effective dose using Ludlum:
The minimum, maximum, average, Geo mean (GM), and standard deviation (GSD) of gamma absorbed dose rates for different petroleum area in Thi-Qar province measured using portable dose survey Ludlum table (2) and used gamma absorbed dose to calculate annual effective dose. Gamma absorbed dose rates in NOF the minimum and maximum value will be (27.63nGy h^{-1}) (31.72nGy h^{-1}) respectively with average (30.49nGy h^{-1}), in AGOF the minimum and maximum value will be (22.13nGy h^{-1}) (33.48nGy h^{-1}) respectively with average (27.01nGy h^{-1}), in SOF the minimum and maximum value will be (21.26nGy h^{-1}) (28.48nGy h^{-1}) respectively with average (24.81nGy h^{-1}) and in TQR the minimum and maximum value will be (10.23nGy h^{-1}) (30.12nGy h^{-1}) respectively with average (21.58nGy h^{-1}) all measuring within the word average range [8]. Annual effective dose rate in NOF the minimum and maximum value will be (0.033 mSv y^{-1}) (0.038 mSv y^{-1}) respectively with average (0.036 mSv y^{-1}), in AGOF the minimum and maximum value will be (0.027 mSv y^{-1}) (0.041 mSv y^{-1}) respectively with average (0.032 mSv y^{-1}), in SOF the minimum and maximum value will be (0.026 mSv y^{-1}) (0.034 mSv y^{-1}) respectively with average (0.03 mSv y^{-1}) and in TQR the minimum and maximum value will be (0.012 mSv y^{-1}) (0.036 mSv y^{-1}) respectively with average (0.026 mSv y^{-1}) all measuring within the word average range [9].

Comparison with the gamma spectroscopic analysis of the soil samples:
Previously, twenty-five samples of soil were collected from all the previously mentioned sites (5 fromNOF, 7 from AGOF, 6 fromSOF, 7 from TQR, samples were taken at a depth of (10-40)cmfrom ground surface [10]. The sample weight was (2-3) kg. All the collected samples are investigated by using gamma-ray spectrometer system.

Table 3 presents the NORM concentrations of ^{232}Th, ^{226}Ra and ^{40}kin the soil samples the values show in **NOF** the minimum and maximum concentrations of ^{232}Th, ^{226}Ra and ^{40}k will be (10.43 to 17.22) Bq kg^{1}, (11.75 to 19.25) Bq kg^{1}, and (359.5 to 452.72) Bq kg^{1} with average (14.73, 14.58 and 413.78) Bq kg^{1} respectively, in **AGOF** the minimum and maximum concentrations of ^{232}Th, ^{226}Ra and ^{40}k will be (13.39 to 18.32) Bq kg^{1}, (5.43 to 19.31) Bq kg^{1}, and (213.67 to 452.72) Bq kg^{1} with average (16.35, 11.86 and 334.01) Bq kg^{1} respectively, in **SOF** the minimum and maximum concentrations of ^{232}Th, ^{226}Ra and ^{40}k will be (17.19 to 19.45) Bq kg^{1}, (9.4 to 14.46) Bq kg^{1}, and (177.44 to 277.45) Bq kg^{1} with average (18.57, 12.18 and 237.59) Bq kg^{1} respectively, in **TQR** the minimum and maximum concentrations of ^{232}Th, ^{226}Ra and ^{40}k will be (4.9 to 20.06) Bq kg^{1}, (8.53 to 14.34) Bq kg^{1}, and (166.37 to 352.34) Bq kg^{1} with average (14.38, 11.01 and 248.61) Bq kg^{1} respectively. Calculated Gamma absorbed dose rates and annual effective doseby previous results table 3 gamma absorbed dose rates in NOF the minimum and maximum value will be (31.38 nGy h^{-1}) (38.78 nGy h^{-1}) respectively with average (34.15 nGy h^{-1}), in AGOF the minimum and maximum value will be (25.63 nGy h^{-1}) (37.41nGy h^{-1}) respectively with average (30.38 nGy h^{-1}), in SOF the minimum and maximum value will be (24.19 nGy h^{-1}) (31.01nGy h^{-1}) respectively with average (27.64 nGy h^{-1}) and in TQR the minimum and maximum value will be (14.77 nGy h^{-1}) (23.59nGy h^{-1}) respectively with average (24.99 nGy h^{-1}) all measuring within the word average range. Annual effective dose rate in NOF the minimum and maximum value will be (0.15 mSv y^{-1}) (0.17 mSv y^{-1}) respectively with average (0.164 mSv y^{-1}), in AGOF the minimum and maximum value will be (0.12 mSv y^{-1}) (0.18 mSv y^{-1}) respectively with average (0.144 mSv y^{-1}), in SOF the minimum and maximum value will be (0.11 mSv y^{-1}) (0.15 mSv y^{-1}) respectively with average (0.13 mSv y^{-1}) and in TQR the minimum and maximum value will be (0.07 mSv y^{-1}) (0.15 mSvy^{-1}) respectively with average (0.117 mSv y^{-1}) all measuring within the word average range.

The measured gamma dose rates using the portable survey-meters and those calculated based on the measured NORM of the collected samples are highly in-correlated. This means the fast measurements by the survey meters cannot be trusted specially for the regions of low NORM. The wide difference between the measurements data of the gamma spectrometer which higher than those by portablesurvey can be attributed to the accuracy difference of theused devices or the difference in measurement time between the gamma spectrometer and the portablesurvey meters, as well as the sample preparation.

Conclusion:-

Radiological survey of oil production areas in Thi-Qar Governorate, southern Iraq, using portable survey devices, as the result of a measurement external exposure using RadEye (PRD), gamma absorbed dose rates and annual effective dose using Ludlum is within the word average range. The obtained results by these survey-meters are compared with those obtained by using gamma-ray spectrometer to analyses of twenty-five samples of soil collected from all the previously mentioned sites andanalysesthem. Hence, we can say the region of petroleum products have no significant radiological risk on the worker or the public as well and on the environment.Using the gamma survey meters to determine the dose rates inside these regions cannot be trusted and the long methodology of the gamma spectroscopic analysis of the collected samples is highly required.

Table (1):- External exposure using RadbEye (PRD) portable survey meter.

Location		External exposure	external exposure
		nGyh^{-1}	**mSvy^{-1}**
NOF	Min	0.15	0.01
	Max	0.18	0.01
	Average	0.17	0.01
	GEOMean	0.17	0.01
	SD	0.10	0.01
AGOF	Min	0.12	0.01
	Max	0.19	0.02
	Average	0.15	0.01
	GEOMean	0.14	0.01
	SD	0.02	0.00
SOF	Min	0.11	0.01
	Max	0.16	0.01
	Average	0.13	0.01
	GEOMean	0.13	0.01
	SD	0.01	0.00

TQR	Min	0.06	0.01
	Max	0.15	0.01
	Average	0.12	0.01
	GEOMean	0.11	0.01
	SD	0.02	0.01

Table (2):- Gamma absorbed dose rates using Ludlum portable survey meter.

Location		Gamma absorbed dose rate ($nGy\ h^{-1}$)	Annual effective dose ($mSv\ y^{-1}$)
NOF	Min	27.63	0.13
	Max	31.72	0.15
	Average	30.49	0.15
	GEOMean	30.46	0.15
	SD	1.45	0.01
AGOF	Min	22.13	0.11
	Max	33.48	0.16
	Average	27.01	0.13
	GEOMean	26.73	0.13
	SD	3.95	0.02
SOF	Min	21.26	0.10
	Max	28.48	0.14
	Average	24.81	0.12
	GEOMean	24.67	0.12
	SD	2.52	0.01
TQR	Min	10.23	0.05
	Max	30.12	0.14
	Average	21.58	0.10
	GEOMean	20.86	0.10
	SD	5.54	0.03

Table (3):- NORM concentration in soil and gamma absorbed dose.

Location		Gamma absorbed dose	
		Absorbed dose rate($nGy\ h^{-1}$)	Annual effective dose($mSv\ y^{-1}$)
NOF	Min	31.38	0.15
	Max	38.78	0.17
	Average	34.15	0.16
	GEOMean	34.11	0.16
	SD	1.47	0.01
AGOF	Min	25.63	0.12
	Max	37.41	0.18
	Average	30.38	0.14
	GEOMean	30.1	0.14
	SD	4.19	0.02
SOF	Min	24.19	0.11
	Max	31.01	0.15
	Average	27.64	0.13
	GEOMean	27.52	0.13

	SD	2.53	0.02
TQR	Min Max	14.77 23.59	0.07 0.15
	Average	24.99	0.12
	GEOMean	24.41	0.11
	SD	4.98	0.02

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