Environmental Assessment of Radioactive Hazards in Wadi Diit area, South Eastern Desert, Egypt

Ahmed Saad, Egyptian Environmental Affairs Agency, Mansoura, Egypt

*corresponding-author ahmeddesouky80@hotmail.com

Abstract. Gamma spectrometric survey has been done using Car-borne and ground survey for the environmental impact assessment of radioactive hazards in the soil of Wadi Diit, Southeastern Desert, Egypt. The measurements of potassium (K, %), equivalent uranium (eU, ppm) and equivalent thorium (eTh, ppm) were done in 741 locations and were converted into specific activities, absorbed dose rate and effective dose rate then compared with internationally accepted values. The most of terrestrial specific activities and effective dose rate in the study area lay within the intentional allowable level for members of the public, except most of K specific activity values are more than the international permissible limits. In general, the study area is radioactive safe due to lower values of effective dose rate where the maximum value was 0.37mSv/yr.

Keywords: Wadi Diit, radioactive hazards, specific activity, effective dose rate.

1 Introduction

The purpose of carrying out Environment Impact Assessment (EIA) is to assist in the decision making process and to ensure that the study area under consideration is environmentally sustainable for any economic, tourist and agriculture projects. Spectrometric survey accumulated using the GIS technique to produce EIA study for preventing, minimizing, mitigating or compensating of adverse impact, so as to achieve a sustainable development. The studies on natural background radiation areas provide a good scope for evaluating biological effects caused by low-level radiation exposures on a long-term basis [1].

Wadi Diit is located between Abu Ramad and Shalateen cities, Southeastern Desert of Egypt, between latitudes 22° 23' N - 22° 39' N and longitudes 36° 4' E -36° 15' E, (Figure, 1a). This site represents one of the areas in Egypt which didn't take much attention in the past. It deserves to be scientifically explored from the geoenvironmental point of view to high lighten their characteristics.

The objectives of this study were to determine the distribution of the radioelements in the study area through the gamma ray spectrometric survey using ground and carborne techniques and conversion radiometric measurements to environmental units to support the decision maker for the development of the area on the basis its environmental assessment.

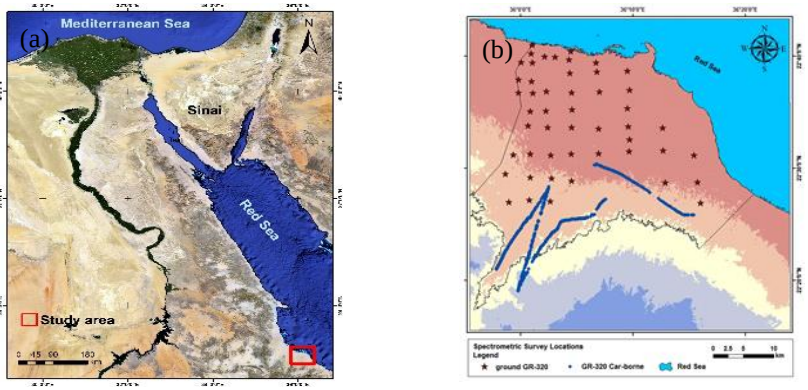


Fig. 1 a) Location map of the study area, **b)** location of gamma-ray measurements.

2 Materials and Methods

The spectrometric survey data were measured at 741 locations (686 locations using GR-320 Car-borne multichannel gamma-ray and 55 locations using a portable GS-265), (Figure, 1b). Specific activity used to describe the radionuclide contents of rocks and building materials [2]. Potassium (K%), uranium (eU ppm) and thorium (eTh ppm) in the investigated areas were converted into specific activities using, as recommended by the International Atomic Energy Agency [3]. The radioelement concentrations (K %, eU ppm and eTh ppm) were converted into exposure rate (µR h-1) and dose rate (nGy h-1). For environmental gamma radiation, effective dose rate can be estimated by the following equation:

$$E = D \times t \times 0.7 \times 10^{-6}$$

Where E is the effective dose (mSv), D is the dose rate in air (nGy h^{-1}), t is the exposure time (h) and 0.7×10^{-6} is the conversion coefficient (Sv Gy^{-1}) for human organs. The effective dose rate (mSv) for 1 % K, 1 ppm eU and 1 ppm eTh was calculated for 1 y (t = 8760 h), using previous equation. The total effective dose rate (ET) of the investigated areas was obtained by summing the effective dose rate of the potassium (EK), uranium (EU) and thorium (ETh) as follows:

$$ET = EK + EU + Eth$$

3 Results

Statistical analyses of measured and converted gamma-ray spectrometric data are given in (Table 1). GIS Spatial analyst used for classifying the selected sites has values more or less within the range of the international permissible limits in raster maps.

The K %, eU ppm and eTh ppm measurements in the study area and their calculated specific activities are grouped in (Table 1). The calculated K-specific activity ranges between 156.5 and 939 Bq kg^{-1}, with mean value 699.2 Bq kg^{-1}, which is mostly more than P.L (permissible limits) in the central and southern part of the study area (Fig. 2a).

The U-specific activity ranges from 0.2 to 44.45 Bq kg^{-1}(Table 1); which slightly more than P.L in the small random scattered area (Fig. 2b), with mean value 14.65 Bq kg^{-1}. The Th-specific activity ranges between 0.1 and 28.42 Bq kg^{-1}(Table 1); which is also slightly more than P.L. with mean value 11.84 Bq kg^{-1}(Fig. 2c). The international permissible levels were (370, 25 and 25 Bq/Kg^{-1}) for potassium, uranium and thorium, respectively [4]. All of the estimated values and the statistical result were interpolated to the enclosing location points using GIS spatial analyst for detected permissible limits zones of (K, U, Th) specific activity respectively.

Table 1. Statistics parameters of radioelement concentrations and their conversions to a specific activity, exposure rate, equivalent dose rates and effective dose rate for the study area.

	Unit	Min	Max	Mean	SD	P.L.
K (%)		0.5	3	2.23	0.41	
eU (ppm)		0.02	3.6	1.19	0.71	
eTh (ppm)		0.02	7	2.92	1.26	
K (spec. Activity)	Bq kg^{-1}	156.5	939	699.2	127.05	370
eU (spec. Activity)	Bq kg^{-1}	0.2	44.45	14.65	8.76	25
eTh (spec. Activity)	Bq kg^{-1}	0.1	28.42	11.84	5.11	25
Total spec. Activity		199.1	959.51	725.69	125.38	
Exposure rate	µR h^{-1}	2.89	7.04	4.97	0.77	
Dose rate	nGy h^{-1}	25.15	61.16	43.22	6.67	
Effective dose rate	mSv y^{-1}	0.15	0.37	0.26	0.04	1

SD: Standard Deviation, P.L. (World average permissible limits, UNSCEAR, 2000)

The results of effective dose rates range from 0.15 to 0.37 mSv y^{-1}, with an average value 0.26 mSv y^{-1}, (Table, 1). Effective dose rate lies within the International Commission on Radiological Protection recommended limits [5] for the occupational workers (20 mSv y^{-1}), and within the dose limit (1.0 mSv y^{-1}) as the maximum annual dose recommended to members of the public as given in the raster map from GIS spatial analyst (Fig. 2d).

4 Conclusions

A ground-based gamma-ray survey has been done on 741 locations in Wadi Diit to establish an Environment Impact Assessment (EIA) of the distribution of the radioelements, K, eU, eTh and to using GIS spatial analyst technique assist in the decision making process and to ensure that the area under consideration is environmentally sustainable. The result from estimated and statistical analysis of (K, U, Th) specific activities, indicate that they are nearly less than permissible limits except for K specific activities in the most study area which is more than the international permissible limits.

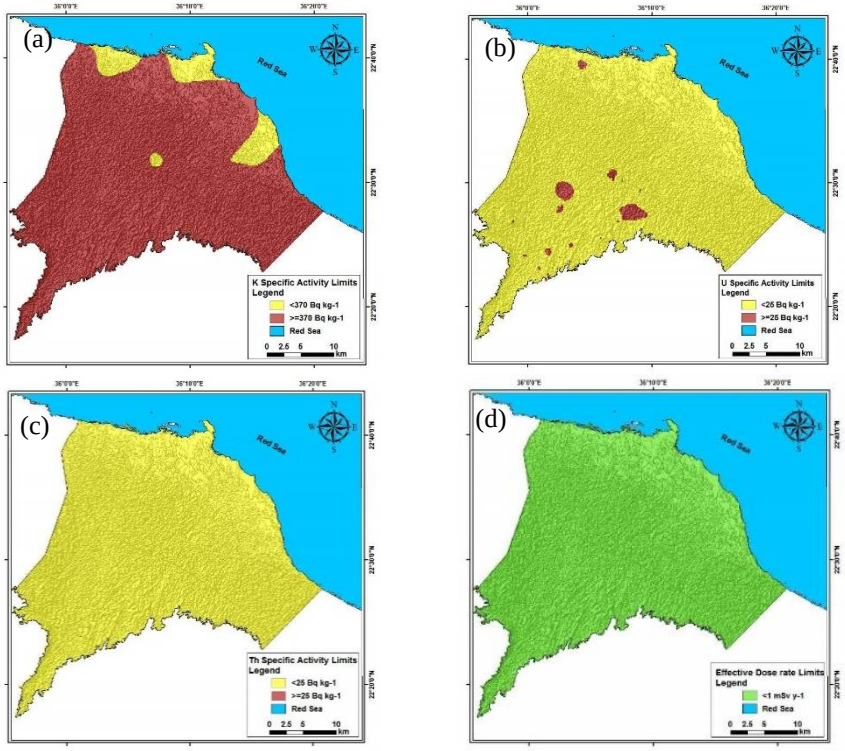


Fig. 2 Environmental monitoring maps of the study area **a)** K-specific activity Bq kg^{-1}, b) U-specific activity Bq kg^{-1}, **c**) Th-specific activity Bq kg^{-1} and **d**) Effective dose rate (mSv y^{-1}).

The effective dose rates recorded in all sites of the study area are less than the international permissible limits. GIS technique produced EIA study to preventing minimizing, mitigating or compensating for adverse impact, so as to achieve a sustainable development.

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