Natural Radioactivity Measurement in Sedimentary Rock Samples Collected From the Bahariya Oasis, Western Desert, Egypt

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Abstract. The specific activities of natural radionuclides in ten sedimentary rocks samples collected from the Bahariya oasis area of Western Desert district, Egypt, have been evaluated. Experimental results were obtained by using a high-purity germanium (HPGe) detector and gamma-ray spectrometry analysis system. It was found that, the sedimentary rocks specific activity ranges from 6.9 to 43.5 Bq kg$^{-1}$ for $^{238}$U, between 0.5 and 33.9 Bq kg$^{-1}$ for $^{232}$Th and between 6.5 and 1007.7 Bq kg$^{-1}$ for $^{40}$K. The activity of the Bahariya Formation rises from base to top and reaches 1007.7 Bq kg$^{-1}$ for $^{40}$K which records the highest in the whole area at all in its upper most glauconitic siltstone, mudstone layer. In addition, it was found that the activity increases with the occurrence of Fe-oxide minerals as in the ferruginous sandstones, glauconite in siltstone and mudstone layers in the Bahariya and Naqb formations. The activity of the carbonate rocks shows the highest in the Naqb Formation (pinky limestone), less in the Qazzun Formation and the lowest in the Khoman Chalk, particularly for Th and K activity. The average value of gamma dose rate (30.04 nGy/h) and the average annual effective dose (0.184 mSv y$^{-1}$) obtained in this study are lower than the worldwide dose rate average value (55 nGy/h) and the maximum annual dose to members of the public (1.0 mSv y$^{-1}$), respectively.

Keywords: Radioactivity; Sedimentary Rocks; Gamma Spectrometry; Bahariya Oasis.
Introduction

The Bahariya oasis is one of the five oases located nowadays in the Egyptian Western Desert (together with the Kharga, Dakhla, Farafra, and Siwa oases). It is set in a depression covering over 2000 Km$^2$ representing the lowest point in Egypt. It is located in the heart of the Western Desert of Egypt between latitudes 27° 48′ and 28° 30′ N and longitudes 28° 32′ and 29° 10′ E, about 370 km southwest of Cairo and 190 km west of Samalut in the Nile Valley (Fig. 1). Due to many populated villages and cultivated lands all over the Bahariya Oasis, the authors aimed to study the natural radioactivity of the area under consideration. This is considered as a step to establish a database reference of radioactivity background levels in the Western Desert region of Egypt.

Fig. 1. Location map showing the general geology of the study area (after Catuneanu et al., 2006).
Geological Setting

A brief description to the lithology of the Bahariya Formation, the Naqb Formation, the Qazzun Formation, the Khoman Chalk and the playa deposits is discussed in the following sections. Comprehensive discussions of the geology and structural setting are given elsewhere by (Ball and Beadnell 1903; El-Akkad and Issawi 1963; Hilmy et al., 1984; Morsy, 1987; Said 1990; Zaghloul et al., 1993; Samir 1994; El Bassouny, 1970, 2004; Catuneanu et al. 2006 and online web page http://www.nilevalleytravel.com-Geology of Egypt).

Bahariya Formation

The Cenomanian Bahariya Formation is the oldest exposed unit in the Bahariya Depression and forms most of the cliffs and slopes surrounding the depression. Gabal El Dist, lies at lat. 28° 25´ N and long. 28° 55´ E, is considered as the type locality of the Bahariya Formation (Ball and Beadnell, 1903; Morsy, 1987; Said, 1990; and Catuneanu et al., 2006). It is represented by dominantly a clastic succession, with lithologies ranging from light colored fine- to very fine-grained sandstones with horizontal lamination (with thicknesses of about 15m) capped by dark gray mudstones and yellow to creamy colored claystones at the base grading upwards into fossiliferous glauconitic siltstones and sandstones (Morsy, 1987; and Catuneanu et al., 2006). Numerous iron-rich paleosol horizons, referred to as ferricretes by Catuneanu et al. (2006), are present almost throughout the Bahariya Formation, Fig. (3b). Columnar Oligocene flood basalt sheets cover the Bahariya Formation at Gebel Mandisha area which is located with the position of 28° 54’ E and 28°22’ N in the Bahariya oasis depression, (Fig.1 & 2).

Fig. 2. Photograph for Gabal Mandisha area, Bahariya Oasis.
Fig. 3. Photograph for Gabal El-Dist (a), base of Bahariya Fm section shows yellow claystone capped by red iron-rich layer (b).

Khoman Formation

The Khoman Formation is made up of massive snow-white chalk and chalky limestone deposited during the Late Cretaceous (Maastrichtian), about 70 million years ago, when the sea covered the vast area of Western Desert (Ball and Beadnell, 1903; El-Akkad and Issawi, 1963; Said 1990; Zaghloul et al., 1993; and Samir, 1994). The chalk, which reflects deep marine conditions, is characterized by a great number of joints filled with calcite veins, small iron-rich pipes and pyrite concretions. The floor of white desert is partly covered by small fragments of pseudomorphs of iron oxides after pyrite (http://www.nilevalleytravel.com-Geology of Egypt). The type section (more than 50 m (164 ft) thickness) is represented in the scarp west of Ain Khoman to the southwest of the Bahariya Oasis (Fig. 1 & 4).

Fig. 4. Photograph for Khoman Chalk in White Desert, west of Ain Khoman, south of the Bahariya Oasis.
Natural Radioactivity Measurement in Sedimentary Rock Samples ...

Naqb Formation

The Naqb Formation belongs to the Middle Eocene and is made up of a succession of pure limestone beds intercalated at the middle part of the formation with dolostones. The limestones are micritic, sparitic and intraclastic at the base, ferruginous in parts, with chalcedony replacing fossil shells and forming geodes (Hilmy et al., 1984; Said, 1990; and El Bassyouny, 1970, 2004). It differentiates to two members: The lower one is mainly dark gray to pink, non-fossiliferous dolomitic and siliceous limestone. While the upper member is fossiliferous limestone beds with minor clay and conglomeratic intercalations.

Qazzun Formation

The Qazzun Formation covers a large tract of the plateau surface north and northwest of the Bahariya Oasis and conformably overlies the Naqb Fm (Hilmy et al., 1984; and Said, 1990). Lagoonal limestone: white to gray to yellowish, thinly-bedded, partly crystalline, partly chalky, occasionally siliceous and/or dolomitic, common calcite pockets. The limestone includes characteristic melon-shaped concretions of siliceous limestone.

Playa Deposits

Remanent of Holocene pluvial lakes have been known in the south Western Desert of Egypt as playa deposits (Said, 1990). They lie mostly at the footslopes of the limestone plateau. Such deposits represent the lowest points of the various enclosed Bahariya drainages and are restricted to small areas on the road near Ain El Heiz village. They are clay flat surface type deposited under fluviatile environment.

Materials and Methods

Samples Collection

Ten rock samples were collected from the Bahariya Oasis particularly from G. El Dist, G. Mandisha, White Desert (west Ain Khoman south the Bahariya Oasis) and surface playa deposits on the road near Ain El Heiz village (Fig. 1). Geologically, such rock samples represent the Bahariya Formation, the Naqb Formation, the Qazzun Formation, the Khoman Chalk and the playa deposits (Fig. 1-4).
**Samples Preparation**

The collected samples were crushed, sieved by a 0.8 mesh, homogenized, mixed and weighed. The samples were stored in Marinelli polyethylene containers of 100 cc. Each sample was carefully sealed for 4 weeks to reach secular equilibrium between $^{220}$Rn and $^{232}$Th and their respective progeny (Mollah et al., 1987).

**Samples Measurements**

For gamma radiation measurements, a coaxial HPGe detector (ORTEC 572A) of sensitive volume of 76.11 cm$^3$ is used. The energy resolution of HPGe detector is 1.9 keV at $^{1332}\gamma$-$^{60}$Co transition. The quantitative and qualitative analysis is achieved by using a Maestro H-EG&G card interfaced with an IBM PC-compatible to work as a Multi-Channel Analyzer (MCA). All gamma measurements are taken after energy calibrating the MCA with $^{241}$Am, $^{60}$Co, $^{133}$Ba and $^{226}$Ra standard sources.

The absolute efficiency calibration of the used detector is determined using potassium chloride solutions to get efficiency value for the energy values of 1460 keV emitted by $^{40}$K. In addition, $^{60}$Co, $^{133}$Ba and $^{226}$Ra standard sources having the same shape and size were used to complete the efficiencies over a wide energy range. The detector is surrounded by a lead cylindrical shield to eliminate the contribution of naturally occurring background radionuclides in the environment. However, the natural background gamma spectrum is obtained and subtracted from each sample spectrum to get more accurate results. All gamma spectra are accumulated for 24 hours and are analyzed after background subtraction.

**Results and Discussion**

**Activity of Natural Radionuclides Estimation**

The results of measurements for ten sedimentary rock samples collected at different locations in the Bahariya oasis area are presented in Table 1. The specific activity of the radionuclides ranged between 6.9 to 43.5 Bq kg$^{-1}$ for $^{238}$U, between 0.5 and 33.9 Bq kg$^{-1}$ for $^{232}$Th, and between 6.5 and 1007.7 Bq kg$^{-1}$ for $^{40}$K. These activities of the radionuclides are represented to two discriminated clastic sequence (Samples 1-6 & 10) and carbonate sequence (Samples 7-9).
With respect to the clastics of the Bahariya Formation, generally the activity rises from its base to its top (as shown from samples S1 to S6 in Table 1). Although samples S1 and S2 are white creamy clays, sample S1, which was collected from Gabal Mandisha location (Fig. 1, 2), has activity of 22.3, 28.1 and 365.1 Bq kg$^{-1}$ for $^{238}$U, $^{232}$Th and $^{40}$K, respectively (Table 1). Whereas, sample S2, which was collected from Gabal El Dist location (Fig. 1, 3), has activity of 11.0, 16.4 and 184.9 Bq kg$^{-1}$ for $^{238}$U, $^{232}$Th and $^{40}$K, respectively (Table 1). In other words, the activity of natural radionuclides of S1 is twice that of S2. This is may be due to that the Gabal Mandisha sample was subjected to hydrothermal alteration that was associated with the basaltic sheet intrusion. The latter covers the Bahariya Fm at Gebel Mandisha area as mentioned in the geological setting section (Fig. 1& 2).

Table 1. Specific activities of radionuclides in sedimentary rock samples at different locations in the Bahariya Oasis area.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Age</th>
<th>Location</th>
<th>Formation name and lithology</th>
<th>$^{238}$U</th>
<th>$^{232}$Th</th>
<th>$^{40}$K</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Mean</td>
<td>St.</td>
<td>Mean</td>
<td>St.</td>
</tr>
<tr>
<td>S10</td>
<td>Holocene</td>
<td>near Ain El Heiz village</td>
<td>Palya deposits</td>
<td>37.9</td>
<td>3.14</td>
<td>33.9</td>
</tr>
<tr>
<td>S9</td>
<td>Middle Eocene</td>
<td>melon-shaped field</td>
<td>Qazzun Fm. (Limestone)</td>
<td>16.6</td>
<td>0.99</td>
<td>0.50</td>
</tr>
<tr>
<td>S8</td>
<td>G. El-Dist</td>
<td>White desert S. Bahariya Oasis</td>
<td>Naqb Fm. (Limestone)</td>
<td>43.5</td>
<td>2.71</td>
<td>3.90</td>
</tr>
<tr>
<td>S7</td>
<td>Maestrichtian</td>
<td>White desert S. Bahariya Oasis</td>
<td>Khoman Chalk</td>
<td>21.3</td>
<td>2.10</td>
<td>0.80</td>
</tr>
<tr>
<td>S6</td>
<td></td>
<td>Galuconite</td>
<td>Mean 60</td>
<td>1.30</td>
<td>6.70</td>
<td>1.08</td>
</tr>
<tr>
<td>S5</td>
<td></td>
<td>Dark gray mudstone</td>
<td>Mean 25.6</td>
<td>2.58</td>
<td>33.9</td>
<td>1.73</td>
</tr>
<tr>
<td>S4</td>
<td>Early Cenomanian</td>
<td>G. El-Dist</td>
<td>Deep brown colored ferruginous S.S.</td>
<td>22.2</td>
<td>3.01</td>
<td>21.2</td>
</tr>
<tr>
<td>S3</td>
<td></td>
<td>Light brown colored ferruginous S.S.</td>
<td>Mean 9.60</td>
<td>1.67</td>
<td>11.5</td>
<td>0.27</td>
</tr>
<tr>
<td>S2</td>
<td></td>
<td>White creamy Clays</td>
<td>Mean 11.0</td>
<td>1.94</td>
<td>16.4</td>
<td>1.63</td>
</tr>
<tr>
<td>S1</td>
<td>G. Mandisha</td>
<td>White creamy Clays</td>
<td>Mean 22.3</td>
<td>1.33</td>
<td>28.1</td>
<td>0.48</td>
</tr>
</tbody>
</table>
On the other hand, the results of the average activity of $^{238}$U, $^{232}$Th and $^{40}$K for the ferruginous sandstone samples displayed interesting results (Table 1; Fig. 5). The activities of the three radionuclides increased from the light brown colored ferruginous sandstone (S3) to the deep brown colored ferruginous sandstone (S4) (Table 1; Fig. 5). Since the Fe-Oxides content increases gradually from (S3) to (S4), the $^{238}$U activity increases from $9.6 \pm 1.67$ to $22.2 \pm 3.01$ Bq kg$^{-1}$, the $^{232}$Th activity increases from $11.5 \pm 0.27$ to $21.2 \pm 1.73$ Bq kg$^{-1}$ and the $^{40}$K activity increases from $138.6 \pm 15.8$ to $183.5 \pm 20.92$ Bq kg$^{-1}$ (Table 1). These results indicate that there is a direct correlation between the increasing of the samples radioactivity and their own iron-oxyde content. Consequently, the radionuclides and the iron minerals are deposited under the same physicochemical-depositional environmental process. Then, the average activity of the dark gray mudstone (S5) is still in continuous increasing for the three radioelements $^{238}$U, $^{232}$Th and $^{40}$K as 25.6, 33.9 and 241.1 Bq kg$^{-1}$ respectively (Table 1; Fig. 5), supporting the increasing activity line from Bahariya Fm base (S2) to top (S5).

![Fig. 5. Ranges of $^{238}$U, $^{232}$Th and $^{40}$K specific activity concentration for ferruginous sandstones (light and deep brown color) and dark gray mud-stone samples.]

The highest K-activity, over the whole area, was recorded for the upper most layer of the Bahariya Formation (S6); it was 1007.7 Bq kg$^{-1}$ (Table 1). Such layer is composed of glauconitic siltstone and mudstone. It is worth to mention, that glauconite, which has chemical formula (K,Na) $(\text{Fe}^{3+},\text{Al,Mg})_2(\text{Si,Al})_4\text{O}_{10}(\text{OH})_2$, is considered a diagnostic mineral that develops as a consequence of diagenetic alteration of sedimentary deposits. The upnormality of potassium content could be
attributed to the presence of potassium and iron constituents and also to
diagenetic alterations.

The activity among the carbonate rocks, which are represented by
three formations; Khoman Chalk (S7), Naqb Fm (S8) and Qazzun Fm
(S9), Naqb Fm (S8) recorded the highest one (Fig. 6). As shown from
(Table 1; Fig. 6) Naqb Fm sample (S8) exhibited an activity of 43.5, 3.9
and 51.4 Bq kg\(^{-1}\) for \(^{238}\)U, \(^{232}\)Th and \(^{40}\)K, respectively. At the same time,
Qazzun Fm sample (S9) exhibited an activity of 16.6, 0.5, and 15.6 Bq
kg\(^{-1}\) for \(^{238}\)U, \(^{232}\)Th and \(^{40}\)K, respectively. Although both Naqb Fm and
Qazzun Fm samples are carbonate rocks and both belong to the same age
(middle Eocene), the radioactivity levels of the Naqb Fm are higher
about three times than the Qazzun Fm samples for \(^{238}\)U and \(^{40}\)K and about
eight times for \(^{232}\)Th (Table 1& Fig. 6). These differences can be
attributed to their content of accessory mineral constitutes. As regards to
the mineralogical content, limestone of the Naqb Fm sample (S8) is
partly siliceous and occasionally dolomitic. It is partly marly with 3.5 m
clay bed near the base of the section. In addition, it acquires its pink color
due to the including ferruginous material with disseminated glauconitic
grains. Whereas, the Qazzun Fm sample (S9) is composed of nummulitic
limestone beds, that are occasionally siliceous and/or dolomitic
particularly south of the Bahariya Oasis, but loss of Fe-oxide minerals as
in the case of the Naqb Fm.

Fig. 6. Ranges of \(^{238}\)U, \(^{232}\)Th and \(^{40}\)K specific activity concentration for carbonate rocks;
Khoman Chalk, Naqb Fm, and Qazzun Fm.
On the other hand, Khoman Chalk sample (S7) displayed average activities of $^{238}$U, $^{232}$Th and $^{40}$K as 21.3, 0.8 and 6.5 Bq kg$^{-1}$, respectively. These activity values are lower than those of both the Naqb Fm (S8) and the Qazzun Fm (S9) particularly the thorium and potassium contents (Table 1; Fig. 6). Although the three formations; Naqb, Qazzun and Khoman Chalks belong to carbonate rocks, these lower activity values can be attributed to its deep marine facies nature since it has Maestrichtian age. In addition, although the uranium activity of the Khoman Chalk (S7) is still lower than the Naqb Fm (S8), it is higher than the Qazzun Fm (S9) (Table 1; Fig. 6). The increasing of the uranium content in the Khoman Chalk, relative to the Qazzun Fm, may be due to the same physicochemical-depositional process associated with the included small iron-rich pipes, pyrite concretions and the small fragments of pseudomorphs of iron oxides.

Finally, the fluviatile environmental mudstone playa deposits sample (S10) revealed considerable high activities of the three radionuclides $^{238}$U, $^{232}$Th and $^{40}$K; 37.9, 33.9 and 248.9 Bq kg$^{-1}$ in sequence. These higher activities could be owing to its depositional nature which yields radioelements leaching in the lowest points of the various enclosed Bahariya drainages at the footslopes of the limestone plateau neighboring rocks.

**Gamma Dose rate ($D_r$) and Annual Effective Dose ($E_{eff}$) Estimation**

Approximately 87% of the radiation dose received by mankind is due to natural radiation sources and the rest is due to anthropogenic radioactivity (Kannan *et al.*, 2002). Natural radioactivity is associated mainly to primordial radionuclides, including the elements belonging to the $^{238}$U, $^{232}$Th and $^{40}$K series. People of the Bahariya Oasis are frequently using natural stones in a wide range for construction purposes without knowing how much level of radioactivity is present in these stones. Therefore, the estimation of the risks to the human health caused by the radioactivity of Bahariya Oasis rocks should be carried out. The values of the external gamma absorbed dose rate in the air and annual effective dose rate can be calculated in terms of the activities of $^{238}$U,
$^{232}\text{Th}$ and $^{40}\text{K}$ in collected samples. The calculations were performed according to the following equation UNSCEAR (2000):

$$D_r = 0.4299 A_U + 0.666 A_{Th} + 0.042 A_K \text{ ...............}(1)$$

Where, $D_r$ is the dose rate in nGy h$^{-1}$ and $A_U$, $A_{Th}$ & $A_K$ are the specific activities (Bq kg$^{-1}$) of $^{238}\text{U}$, $^{232}\text{Th}$ and $^{40}\text{K}$, respectively.

The calculated $D_r$ can be used to assess the annual effective dose rate equivalent ($E_{eff}$) by the following relation:

$$E_{eff} = D_r (\text{nGy h}^{-1}) \times Q \times T \times \frac{10^3 (\text{mSv})}{10^9 (\text{nGy})} \text{ ...............}(2)$$

where $D_r$ is the absorbed dose rate (in nGy/h), $Q$ is 0.7 (Sv Gy$^{-1}$ y$^{-1}$) for environmental exposure to gamma rays of moderate energy and $T$ is the time in hours in one year, i.e., 8760 h. To deduce the indoor occupancy (i.e. human effective dose) and outdoor exposure to gamma rays, the $E_{eff}$ results should be multiplied by factors of 0.8 and 0.2 adopted by the UNSCEAR (2000).

It is noticeable from Table (2) that the highest absorbed dose values are recorded for the collected samples of glauconite (S6), playa (S10), dark gray mud-stone (S5) and white creamy clays of G. Mandisha (S1). The lowest values are recorded for the carbonate rocks; Qazzun Fm (S9) and Khoman Chalk (S7), as well as the light brown colored ferruginous sandstone (S3). In addition, Table (2) shows that, the absorbed dose rate values of the Bahariya area vary from 8.1 to 49.8 nGy h$^{-1}$, with a mean value of 30.04 nGy h$^{-1}$. These mean values are lower than the estimate of average global terrestrial radiation of 55 nGy h$^{-1}$ (UNSCEAR, 1988) and are lower than the mean values of sedimentary rocks from Upper Egypt (Abbady, 2004). The calculated annual effective dose with average value (0.184 mSv y$^{-1}$) is lower than the worldwide recommended value to members of the public (1.0 mSv y$^{-1}$ is the maximum permissible annual effective dose limit according to ICRP, 1990).
Table 2. The absorbed dose rate, annual effective dose, indoor and outdoor absorbed dose.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Absorbed Dose in Air ((D_r)) (nGy/h)</th>
<th>Annual Effective Dose Rate ((E_{eff})) (mSv/y)</th>
<th>Absorbed dose indoor (mSv/y)</th>
<th>Absorbed dose outdoor (mSv/y)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean st. dev.</td>
<td>mean st. dev.</td>
<td>mean st. dev.</td>
<td>mean st. dev.</td>
</tr>
<tr>
<td>S10</td>
<td>49.3 115.2</td>
<td>0.30 0.71</td>
<td>0.242 0.565</td>
<td>0.060 0.141</td>
</tr>
<tr>
<td>S9</td>
<td>8.1 2.0</td>
<td>0.05 0.01</td>
<td>0.040 0.010</td>
<td>0.010 0.002</td>
</tr>
<tr>
<td>S8</td>
<td>23.5 6.5</td>
<td>0.14 0.04</td>
<td>0.115 0.032</td>
<td>0.029 0.008</td>
</tr>
<tr>
<td>S7</td>
<td>10.0 2.4</td>
<td>0.06 0.01</td>
<td>0.049 0.012</td>
<td>0.012 0.003</td>
</tr>
<tr>
<td>S6</td>
<td>49.8 114.9</td>
<td>0.31 0.70</td>
<td>0.244 0.564</td>
<td>0.061 0.141</td>
</tr>
<tr>
<td>S5</td>
<td>43.7 27.7</td>
<td>0.27 0.17</td>
<td>0.214 0.136</td>
<td>0.054 0.034</td>
</tr>
<tr>
<td>S4.</td>
<td>31.4 21.1</td>
<td>0.19 0.13</td>
<td>0.154 0.104</td>
<td>0.038 0.026</td>
</tr>
<tr>
<td>S3</td>
<td>17.6 15.9</td>
<td>0.11 0.10</td>
<td>0.086 0.078</td>
<td>0.022 0.019</td>
</tr>
<tr>
<td>S2</td>
<td>23.4 21.2</td>
<td>0.14 0.13</td>
<td>0.115 0.104</td>
<td>0.029 0.026</td>
</tr>
<tr>
<td>S1</td>
<td>43.6 41.6</td>
<td>0.27 0.26</td>
<td>0.214 0.204</td>
<td>0.054 0.051</td>
</tr>
<tr>
<td>Average</td>
<td>30.04 0.184</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Conclusion**

Gamma-ray spectrometry has been utilized to determine the \(^{238}\)U, \(^{232}\)Th and \(^{40}\)K specific activity concentration in ten samples of different types of sedimentary rocks collected from Bahariya Oasis. The specific activity of the radionuclides ranged between 6.9 to 43.5 Bq kg\(^{-1}\) for \(^{238}\)U, between 0.5 and 33.9 Bq kg\(^{-1}\) for \(^{232}\)Th and between 6.5 and 1007.7 Bq kg\(^{-1}\) for \(^{40}\)K. It is noteworthy that, the activity increases with the occurrence of Fe-oxide minerals as in the ferruginous sandstones, glauconite in siltstone and mudstone layers in the Bahariya Formation and the pinky limestone Naqb Formation. Estimation of the external gamma absorbed dose rate in the air at 1 meter above ground level and annual effective dose rate are carried out. The average value of gamma dose rate (30.04 nGy/h) and the average annual effective dose (0.184 mSv y\(^{-1}\)) obtained in this study are lower than the worldwide dose rate
average value (55 nGy/h) and the maximum annual dose to members of the public (1.0 mSv y⁻¹), respectively.

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قياس النشاط الإشعاعي الطبيعي لعينات من الصخور الرسوبية
تم جمعها من الواحات البحرية، الصحراء الغربية، مصر

سامي عبدالنبي٢، ونبيل الزهاوي٢، ويزينب مرسي٢، وإيمن سالم٢
قسم الجيوفيزياء، قسم الفيزياء، كلية العلوم، جامعة عين شمس، القاهرة
قسم الفيزياء، كلية البنات، جامعة عين شمس، القاهرة

المستخلص. تناول البحث تقييم أنشطة محدودة من العناصر المشعة
الطبيعية في عشر عينات من الصخور الرسوبية التي تم جمعها من
منطقة الواحات البحرية بالصحراء الغربية، مصر. تم الحصول على
النتائج التجريبية باستخدام مقياس الجرمانيوم عالي النقاء (HPGe)
و نظام التحليل الطيفي لأشعة جاما. فقد وجد أن النشاط المحدد يتراوح
ما بين 6.9 إلى 13.5 بيكريل كجم٠١ للثوريوم، وما بين 2.5 إلى 3.9
بيكريل كجم٠٢ للثوريوم، ويبقى نشاط منتكون البحرية من
القاعدة إلى القمة ويصل إلى 2.7 بيكريل كجم٠٣ للثوريوم،
والتي تسجل أعلى المعدلات في المنطقة كلها على الإطلاق في
طبقة الغرين والطين العليا الغنية بالجلوكونيت. بالإضافة إلى ذلك،
فقد وجد أن النشاط يزداد بوجود معادن أكاسيد الحديد كما في الحجر
الرومي الحديدي، وطبقات الغرين والطين الغنية بالجلوكونيت في
مكونات البحرية والنقيب. ويبين نشاط صخور الكربونات أن أعلى
المعدلات متماثلة في تكوين النقب (الحجر الجيري ذو اللون الوردي)،
وأقل في تكوين الكازون، وأدناها في تكوين الخومن الطباشيري، ولا
سبباً نشاط الثوريوم والبوتاسيوم. ووجد أن متوسط قيمة معدل جرعة
جاماً (30.04 nGy/h) ومتوسط الجرعة الفاعلة السنوية

Sami Abd El Nabi et al.
Natural Radioactivity Measurement in Sedimentary Rock Samples ...

(0.184 mSv y⁻¹) للتيتين تم الحصول عليهما في هذه الدراسة هي أقل من قيمة الجرعة المتوسطة للمعدل العالمي (55 nGy/h) والجرعة السنوية القصوى لأفراد الجمهور (1.0 mSv y⁻¹) على التوالي.