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Short Communication

Radiation doses due to natural radioactivity in Wadi Bin Hammad, Al-Karak and Jordan

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This paper aims to introduce original data from measurements conducted in Wadi Bin Hammad, region, Jordan. These data highlight the new result of high-radiation dose equivalents found in part of the region, and also recommend further studies. The exposure rates due to terrestrial gamma radiation were measured in cold and hot water in Wadi Bin Hammad cold and hot water springs. The radiation levels were measured using a portable Geiger-Muller counter and an NaI (Tl) detector. The measured absorbed dose rates in air ranged from 15-30 nGyh^{-1} in cold and 100 to 2740 nGyh^{-1} in hot water spring areas. The maximum high radiation dose was found nearby the principal hot water source. The gamma doses outside this region were around 30 nGyh^{-1}, which is very low.

Key words: Hot spring, radiation level, Na(TI)detector, absorbed dose rates.

INTRODUCTION

The natural radioactivity in our environment has been investigated intensively in the last years due to public concern of radiation – induced health hazard. Natural radioactive mineral deposits are found in suitable geological environment. The greatest contribution to mankind's exposure comes from natural background radiation, cosmic natural background radiation and cosmic radiation, and the worldwide average annual effect dose is 2.4 mSvh (UNSCEAR, 2000). Al-Jundi et al. (2003) calculated the absorbed dose resulting from ^{238}U, ^{232}Th and ^{40}K radionuclides in soil core obtained along the desert highway. They found annual effective dose equivalent to be in the range of 40 – 151 $\mu Sv/y$ which is within the range of outdoor radiation exposure given in the UNSCEAR (2000) report (Al-Jundi et al., 2003). Al Hamarneh et al. (2003) studied soil samples from different areas of Jordan. The calculated effective dose equivalent due to ^{137}Cs was found to be more than 200 $\mu Sv/y$.

The hot springs, which are used by the inhabitants and visitors as spas, are the main sources of natural radiation for the distribution of radionuclides such as U^{238} and Th^{232} and their decay products in rock and soil. Many high radiation areas have been identified in several area of the world for example Rasmer in Iran, Yangjiang in China, kerala in coast of India, the Nile Delta in Egypt, and Afra spa in Jordan (Ajlouni et al.,2009; 2010).

Wadi Bin Hammad valley, located near Al-karak (120 km south of Amman), is about 30 km long. It contains many cold water springs, and ends with a hot spring. This valley starts at an 800 m altitude above the sea level, and ends 380 m below the sea level (Figure 1). Hot springs, which are used as spas by visitors from inside and outside Jordan, are the main source of natural radionuclides as well as radiation doses for the public in this part of the country.

The above useful application of natural radioactivity may quantitatively be used as an indicator for environmental contamination. Therefore, it is crucial to determine the baseline of natural radiation and radioactivity such that man-made contamination can be contrasted from natural radioactivity. This additionally makes it possible to detect contamination instantly and thus ensure appropriate measures against the risk of human health (Al-Jundi, 2001). Due to these and other reasons, there have been varied interests worldwide in natural radiation exposure.

This study briefly introduces some data of dose and radiation in Wadi Bin Hammad hot spring and further complements a few studies to measures the dose and radiation rate in Jordan. It introduces more information about radioactivity dose in tourism places in Jordan.

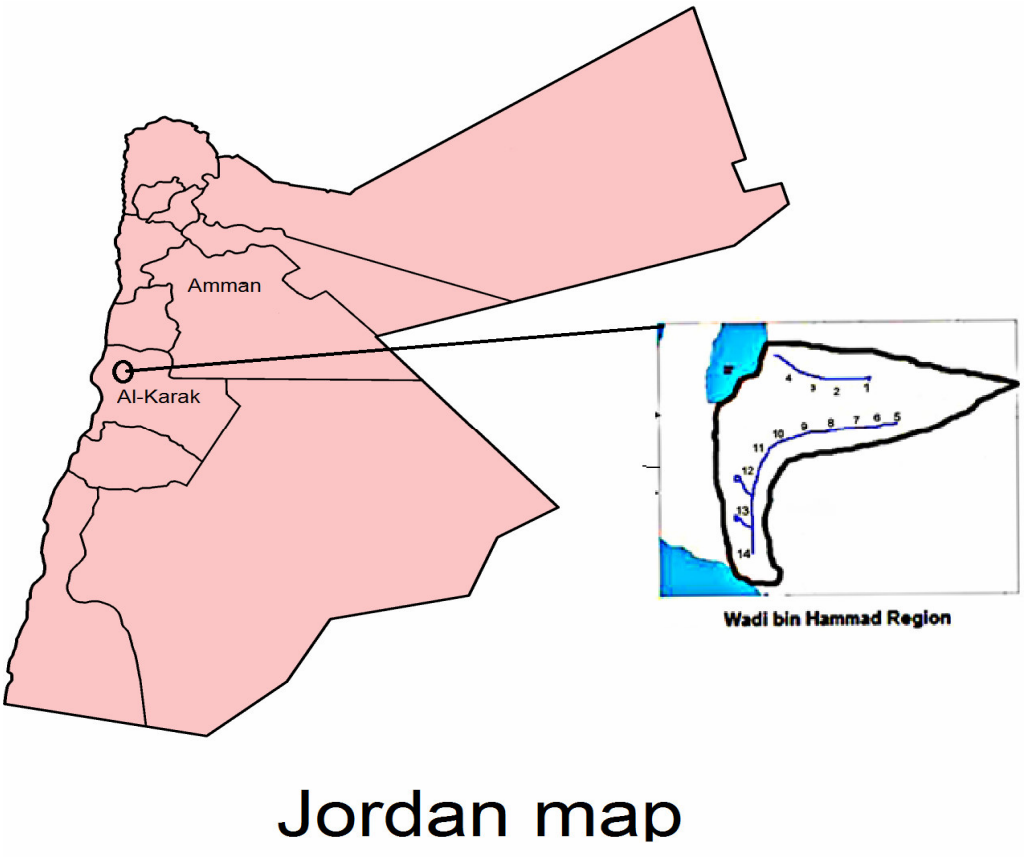

Figure 1. Wadi Bin Hammad valley.

Table 2. Dose rate in air from natural radionuclides.

Region	Dose rate (nGyh^{-1})
1	15
2	25
3	20
4	30
5	60
6	78
7	82
8	100
9	1080
10	1230
11	1340
12	2450
13	2570
14	2740

This study go with the other studies which were done at different areas in Jordan (Ahmad et al., 1997; Al-Jundi, 2002; Al-Jundi et al., 2003; Al Hamarneh et al., 2003; Ajlouni et al., 2009; 2010).

MATERIALS AND METHODS

We used two methods to measure the rate of external gamma radiation level in different zones in Wadi Bin Hammad. The first method involved the use of a portable radiation monitor (RADIAGEM 2000) to measure gamma dose with a Geiger-Muller counter while the second method was implemented by an external probe connected to RADIAGEM 2000 which is a gamma probe with an NaI(T1) $1'' \times 1''$ detector, to measure the dose rate. The second method is used for medium sensitivity with a dose-rate range from 10 nGy h^{-1} to 200 µGy h^{-1} (Ajlouni et al., 2009, 2010). Continuous measurements were done using the two detectors in the whole area with water pools and rocks. The recording of measurements of each point was done.

RESULTS

Table 2 represents the gamma dose rates at 1m above the ground in Wadi Bin Hammad. The doses in air at a height of about 1 m above the ground ranged from 15-30 nGyh^{-1} in cold water, and from 100 to 2740 nGyh^{-1} in hot spring area. The maximum high radiation dose was found nearby the principal hot water source. The gamma doses outside this region were around 30 nGyh^{-1}, which is very low compared to other areas in Jordan.

The highest registered dose rate was near the source

Table 1. The highest registered gamma absorbed dose rates in the world (Ajlouni et al., 2009, 2010).

Country	Area	Characteristics of area	Absorbed dose rate in air ($nGyh^{-1}$)
Iran	Rasmar	Spring waters	70-17000
India	Kerala	Monazite sand, coastal areas	200-400
India	Orissa	Monazite sand, coastal areas	200-400
France	Southwest	Uranium minerals	10-1000
Brazil	Guarapari	Monazite sand, coastal areas	90-1800
Taiwan	Peitou	Spring water	400
China	Yangjiang	Monazite particles	370 average
Pacific	Niue island	Volcanic soil	1100 maximum
Jordan	Afra spa	Hot springs	10-1800
Jordan	Afra spa	Rocks	4×10^6

of hot spring and minimum value in cold water course (Table 1). The external terrestrial gamma radiation absorbed dose was due to concentration of radionuclides of the U^{238} and Th^{232} series.

DISCUSSION

Dose rates in points 12, 13, and 14 are higher than those in other points because these points represent the water pools and source of thermal water. The national average ranges from 24 to 160 $nGyh^{-1}$, where the world–wide average annual effected dose is approximately 70µSv (UNSCEAR, 2000; 2006).

Natural Radioactive isotopes emit different types of radiations with different energies in its decay chain. Since the most important contribution radiation is the gamma, we concentrated on the absorbed gamma dose rate in air. The external dose rate of the high radiation zone was measured to be 2740 nGy/h. This was approximately more than 50 times greater than the dose rates obtained outside the high radiation zone. The possible sources of these doses are the natural Uranium and Thorium series which are highly concentrated. Further investigation should be done using gamma spectroscopy techniques based on NaI(Tl) detector for high energies and HPGe detector for low energies. These investigations will be utilized to estimate the concentration of actual ^{238}U and ^{232}Th.

Conclusion

It can be concluded that radiation doses in Wadi Bin Hammad region surveyed was found to be from 15-30 $nGyh^{-1}$ in cold water and 100 to 2740 $nGyh^{-1}$ in hot spring area and the maximum dose was measured in water source. More research on the effect of high natural radiation on human, animals and plants should be done. Long-term monitoring of health status of residents and worker in this region should also be done.

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