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RADIATION ABSORBED DOSE RATES IN THE DEAD SEA REGION, JORDAN

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ABSTRACT

The present study introduces measurements of natural radiation doses due to gamma radio-nuclides in the Dead Sea, Jordan. This exploration implemented in the famous natural curative resource in Jordan, the Dead Sea. Our measurements show that this region has a proper level of external radiation due to gamma radionuclides, it lies within the normal levels of worldwide. The average registered gamma absorbed dose rates along the Dead Sea region is 75 $nSvh^{-1}$. The range is between 16 to 260 $nSvh^{-1}$.

Keyword: Dead Sea, radiation, radiation hormoses, gamma radionuclides, black mud, radon.

INTRODUCTION

Assessment of natural doses from natural sources is generally the largest contribution to the collective dose equivalent in the population. The principle sources of natural radiation are cosmic rays, terrestrial, internal radiation and radon gas (UNSCEAR, 2006). Cosmic rays are source of radiation that originates from outer space; the sun and stars. The primary cosmic rays that are incident on the earth's atmosphere are mainly protons, alpha particles, gamma rays, X-rays, electrons and a small number of heavier nuclei. Carbon-14, Tritium-3 and Beryllium-7 are examples of cosmogenic radionuclides which are produced by bombardment of stable nuclides by cosmic rays (NCRP, 1987; UNCECAR, 1993; Bennett, 1997).

Terrestrial radiation is coming from a number of radioactive materials occur naturally in the earth (UNCECAR, 1993; UNSCEAR, 2000), Important examples of radioactive atoms that are still present in the earth are those who have a very long half lives. Those are such as Uranium-235, Uranium-238, Thorium-232, and Potassium-40. These isotopes emit alpha and beta particles and gamma rays. They exist in soil, water and vegetation and in the bodies of the human and animals.

A significant part of the total dose contribution in the forms of natural sources comes from terrestrial gamma radionuclides (UNSCEAR, 2000). The main natural contributions to external exposure from gamma rays are Uranium-238, Thorium-232 and Potassium-40 (UNSCEAR, 2000; UNSCEAR, 2006). The radon gas is also an important source of natural radiation. It has two isotopes radon-220 (Rn^{220}, Thoron) and radon-222 (Rn^{222}, Radon). Both of them are radioactive and result either from decay of uranium-238 or thoium-232 (Kaplan, 1984; Walker *et al.*, 1984).

Recently, Radiation Hormesis becomes one of the hottest areas in the radioactivity studies. It suggests that a low-level radiation doses motivates protective biological actions at the cellular, molecular, and organism levels, decreasing cancer and other deleterious health effects incidence rates below spontaneous levels (Henschler, 2006; Calabrese and Baldwin, 2001; Calabrese and Baldwin, 2006). Its effects include preventing and modulating aging and its related impairments, enhancement of antioxidant defenses, enzymatic repair of DNA, removal of DNA lesions, apoptosis, and immunologic stimulation.

The radioadaptive response to low-dose radiations is associated with increased lifespan as well as decreased mutations, chromosome aberrations, neoplastic transformation, congenital malformation, and cancer (Luckey, 1982; Luckey, 1999; Feinendegen, 2005).

Hormesis has demonstrated for many diseases, including cardiovascular disease, diabetes, and cancer. Low dose of ionizing radiation improve the health of the people with less diseases (Kant *et al.*, 2003; Jaworowski, 1995). Although radiation hormesis data are still incomplete, extensive epidemiological studies have indicated that radiation hormesis is really exist. Many examples of this irrefutable evidence is given in different cases such as (Mifune *et al.*, 1992, Mine *et al.*, 1990; Nambi and Soman, 1987; Frigerion and Stowe, 1976; Kumatori *et al.*, 1980; Cohen, 1998). So it is important to initiate studies to investigate areas with low level of radiation, which are good for health and reduce the possibility of having diseases.

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Radiometric data have collected in many countries around the world, using gamma ray spectroscopy methods. This study focuses on the Dead Sea region, which is located in the Jordan valley. It is one of the most well known health seaside resort places around the world. Our aim is to measure the doses of external exposures all around the region, in order to clarify its therapeutic importance and level of ionized radiation.

Regional Geomorphology

Dead Sea, the Salty Sea is a hypersaline lake with its surface and shore are 423 meters below sea level. The Dead Sea is 377m deep, the deepest hypersaline lake in the world. The Dead Sea is 67km long and 18km wide at its widest point. The exact composition of the Dead Sea water varies mainly with season, depth and temperature. The sea is rich in minerals, the concentration of ionic species (in g/kg) of Dead Sea surface water is Cl^- (181.4), Br^- (4.2), SO_4^{-2} (0.4), HCO_3^- (0.2), Ca^{+2} (14.1), Na^+ (32.5), K^+ (6.2) and Mg^{+2} (35.2).

It was one of the world's first health resorts and it has been the supplier of a wide variety of products, which used for fertilizers or cosmetics. The Dead Sea area has become a major center for health research and treatment for several reasons; these such as the mineral content of the water, the very low content of pollens and other allergens in the atmosphere. The Dead Sea becomes the good-place for different types of therapies, which are good for relieving different diseases. Some of those diseases are cystic fibrosis, skin disorder psoriasis, acne, atopic dermatitis, vitiligo (Halevy *et al.*, 1997).

A gray-black mineral-rich mud is deposits on dead seaside due to the Runoff streams. It can help in keeping the human skin feeling healthy and young, and used for treatment of different diseases such as acne, psoriasis, rheumatism, psoriasis, eczema and joint diseases. The major minerals present in this mud are Silicon dioxide (20%), Calcium Oxide (15.5%), Aluminum Oxide (4.8%), Magnesium Oxide (4.5%) Iron(III) Oxide (2.8%), Sodium Oxide (1.7%), Potassium oxide (1.3%), Titanium(IV) Oxide (0.5%), Sulfur trioxide (0.4%), Phosphorus pentoxide (0.3%), Chloride (6.7%), Bromide (0.2%).

MATERIALS AND METHODS

Methods and Measurements

External gamma dose rate levels were measured in two ways. The first way is by using a portable radiation monitor (RADIAGEM 2000), a survey meter that includes an energy-compensated G-M tube. The second way is implemented by an external probe connected to RADIAGEM 2000; the new Canberra Smart Probes SG-1R is designed for gamma radiation measurements. SG-1R, which is a gamma probe with an NaI(Tl) 1"x1" detector, is not energy dependent, but it measures the dose rate equivalent. It is used for medium sensitivity with a dose-rate range from 10 nGy h^{-1} to 200 mGy h^{-1}.

Continuous measurements were done using the two detectors in the whole area, with a continuous recording of measurements. We started our data acquisition from the far southern point of the Dead Sea to the far northern point, passing through agricultural, industrial and tourist regions.

RESULTS AND DISCUSSION

All living organisms live and grow in environments packed of ionizing radiation, external as well as internal. For most of the scientists and public it is no doubt that low doses of ionizing radiation produce negative effects comparative to the effects produced by high-level radiation. Though it was reported that low-dose ionizing radiation is not only a harmless agent but often has a positive effect. That is, low doses of ionizing radiation are an essential dynamism factor for life, analogous to many vital trace elements. This idea leads to propose that part of cancer fatalities is avoidable by exposing to a low dose radiation.

A major part of the total dose contribution comes from gamma radiation from naturally-occurring radionuclides in the U-238, Th-232 series and Potassium-40 (K-40). Wherever there is potassium, where the Dead Sea is very rich with, there is potassium-40. If there is enough potassium, the K-40 can be detectable with a simple survey instrument. Thus direct radiation dose measurements can be used to measure the gamma dose rate; this can be done using the survey meters described in the Experimental section. The gamma dose rate measurements are done 1 m above the ground on the sampling points. The sampling points were selected randomly while driving along the road starting from southern end, Fifa, up to the northern end of the Jordanian side of the Dead Sea. Sampling points are shown in figure 1.

Table 1 gives the registered gamma absorbed dose rates in the randomly selected points. The first point is noticed to have a large dose rate; which is due to the present of the agricultural fertilizers, which contains some radioactive compounds such as phosphorus (P) and potassium (K). Sample point 3 is located near the Arab Potash Company (APC) in the Jordanian side of the Dead Sea and has a 100 nSv/h which is little higher than that of the world range of 18-93nGyh^{-1} (UNSCEAR, 2000). These measurements are sketched in figure 2. Part of the results is in the same level as the results obtained in hot springs in Jordan, except Afra hot spring doses; while many of the results are lower than these (Ajlouni *et al.*, 2009; Ajlouni *et al.*, 2010; AL-Amairyeen, 2010; Al-Okour, 2011).

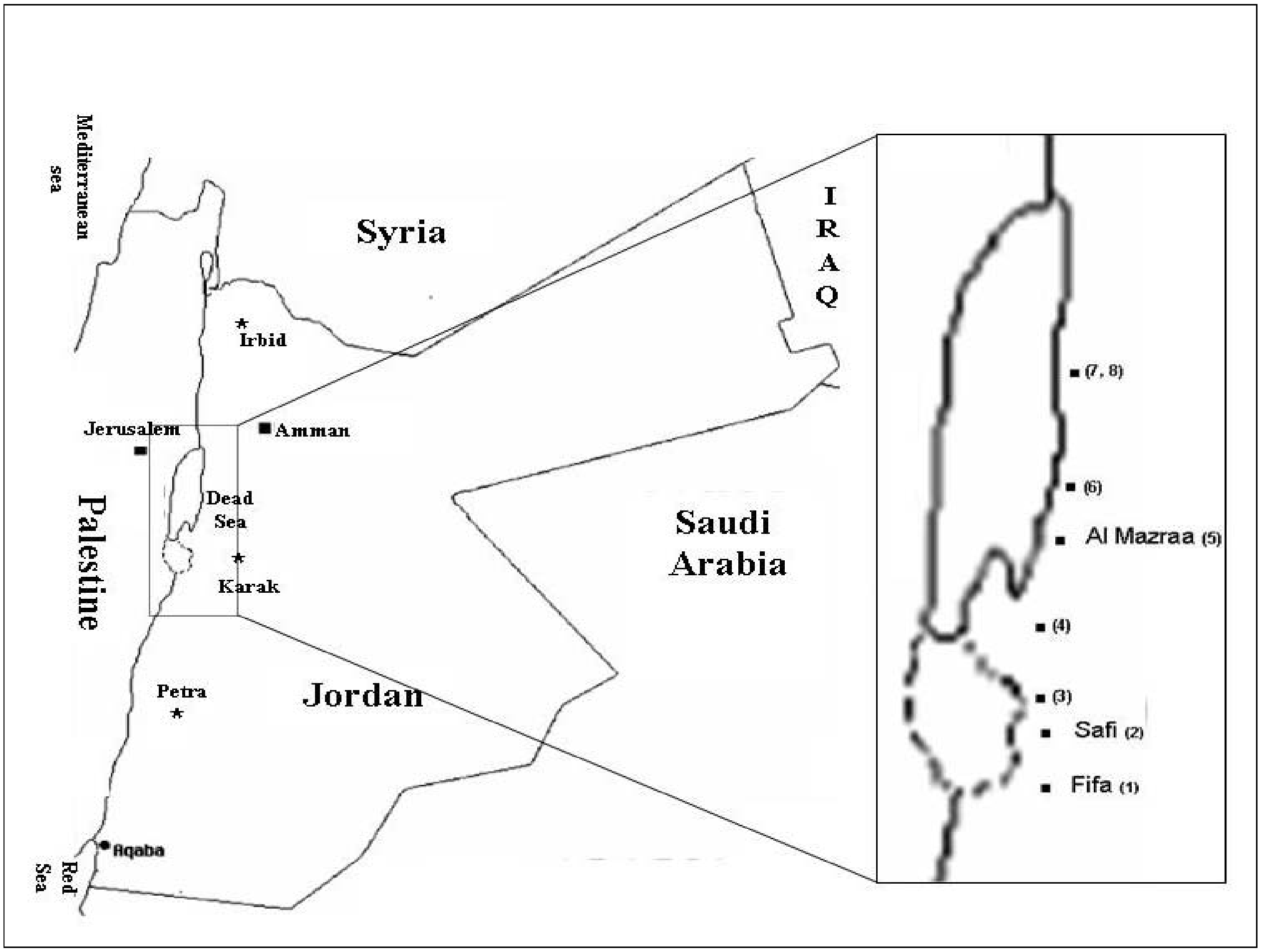

Fig. 1. The Sampling points along the Dead Sea.

Table 1. Registered gamma absorbed dose rates in different points along the Dead Sea region (from south to north).

Location	Characteristic of location	nSv/h
1	Fifa	260
2	Safi	105
3	Near Arab Potash Company (APC)	100
4	Esal	60
5	Al-Mazra'a	60
6	5 km from Al-Mazra'a to the north	130
7	Dead Sea Health Centre number one (DSHC.1)	45-85
8	Dead Sea Health Centre number two (DSHC.2)	30-50

Table 2 gives the dose rate in air in different locations at the Dead Sea Health Center number one (DSHC.1), which is located 50 km from Amman, the capital of Jordan. These locations vary in their distances from 500 meter away from the seaside up to the water body of the sea. The dose rates are increased as we approach the black-mud region, which resides on the seaside as shown in figure 3. Spot (7) which measured on the top of the Black-Mud register the highest dose in the DSHC.1 (80-85 nSv/h). Spot 8 shows the smallest dose on the whole study region, this value is because of the existing of the salt which is covered the mud and limited the radioactivity rate. The dose rate from results the water body ranges from 50 to 60 nSv/h.

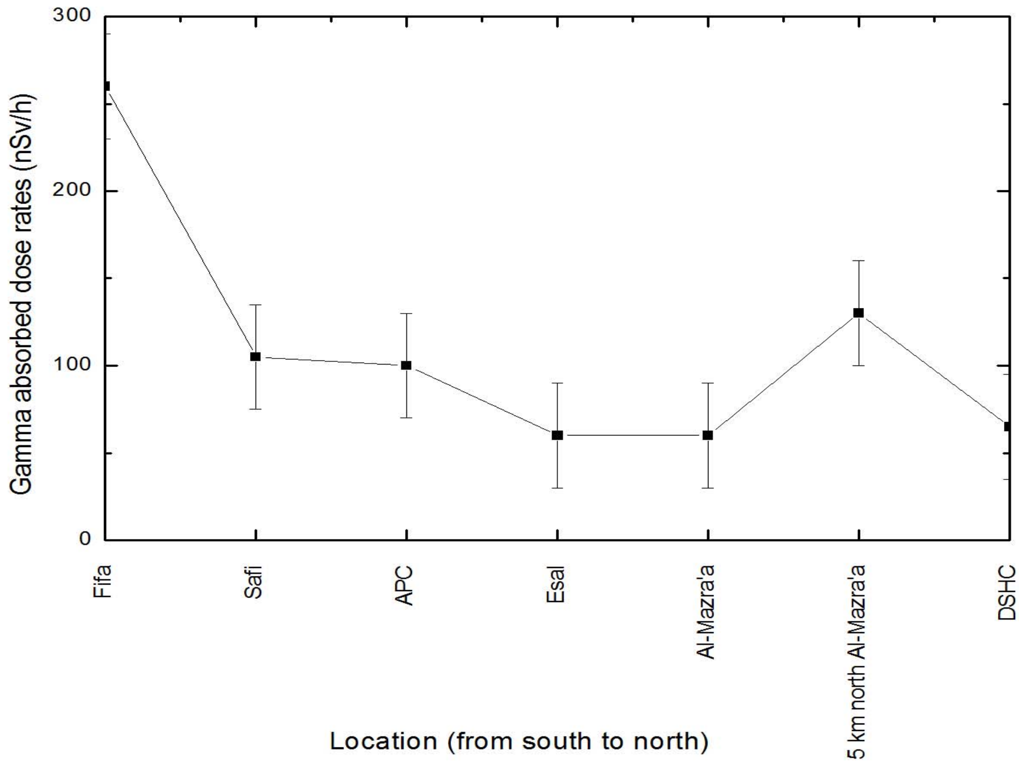

Fig. 2. The Measured Gamma absorbed doses at different locations along the Dead See from south to north.

Table 3 shows the dose rates in air at different locations in the Dead Sea Health Center number two (DSHC.2). These locations vary in its distance from the seaside (from 700m up to 1m and on the top of the sea side). The dose rates in all locations are between 30-50 nSv/h. Location Number 3 has residences of black-mud and show a dose rate of 50 nSv/h.

Table 2. Registered gamma absorbed dose rates at different locations inside the DSHC.1.

Location No.	Distance from the seaside (m)	Characteristic of location	nSv/h
1	500	Center Hall	50
2	400	Near first swimming pool	55
3	300	Near second swimming pool	45
4	200	On the coast	60
5	100	On the coast	70
6	1	Near the water	70-77
7	1	Top of the Black-Mud	80-85
8	1	Top of the salt	15
9	0	Water-body	50-60

Table 3. Registered gamma absorbed dose rates at different locations inside the (DSHC.2).

Location No.	Distance from the seaside (m)	Characteristic of location	nSv/h
1	700	Hotel Hall	40-50
2	100	On the coast	30-40
3	1	On the coast	50
4	0	Water-body	50

Natural radiation doses, someone gets in staying in this region, go together with other features like hot and mineral springs, mud baths and wraps, herbal baths, exposing to sun and dry climate and salt lakes will demonstrate its good effect on stimulating the psychological state of the patient and accelerating his recovery, and improve the health of non-patients.

CONCLUSION

The Dead Sea is one of the important health resorts on the world because of its location, environment and the compound that is used from it. Our data shows that this region has a proper level of external radiation. The gamma dose rates were between 15 $nSvh^{-1}$ and 260 $nSvh^{-1}$. The average dose on all the sampling points is 75 $nSvh^{-1}$

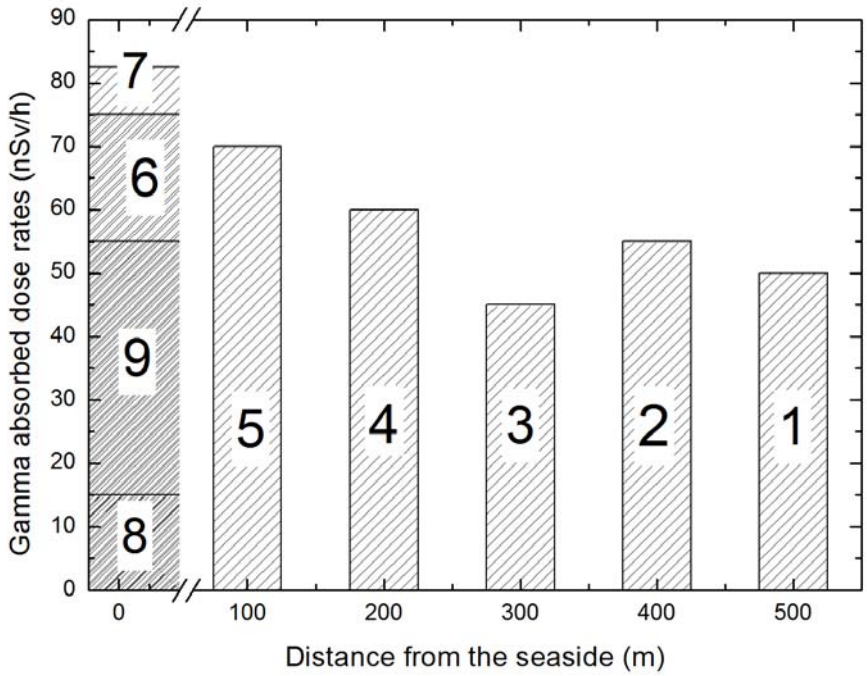

Fig. 3. Dose rates as measured at different locations inside the (DSHC.1) starting from 500m away from seaside till the water body.

which is in not far a lot from the average worldwide external exposure rates from terrestrial gamma radiation of 57 $nGyh^{-1}$. The average rate of the gamma dose is in the world range of 18-93 $nGyh^{-1}$.

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