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Original Article

Evaluation of High Level Environmental Background Radiation Areas and its Variation in Ramsar

Tayyeb Allahverdi Pourfallah[1*], Hamed Babapour[2], Maryam Shahidi[1]

Abstract

Introduction
The exposure of human beings to ionizing radiation from natural sources is a continuing and inescapable feature of life on earth. For most individuals, this exposure exceeds that from all man-made sources combined.
Materials and Methods
In this study, the annual effective dose in high level environmental background radiation areas (HLEBRAs) of northern city of Ramsar in Iran was determined. For dosimetry, a gamma radiation dosimeter was used. Measurements were performed in more than 90 points in five districts with HLEBR around and near hot springs.
Results
In some areas, the annual effective dose from outdoor external gamma radiation in HLEBRAs (30 mSv/y) exceeded the annual effective dose limit for radiation workers. Our results are evident that the population dose from normal background radiation in HLEBRAs is 200 times higher than corresponding values in Ramsar sea shore. To estimate the cosmic ray contribution, dose measurements were performed on the sea surface one km off the sea shore.
Conclusion
The observed differences over locations and measured doses between this study and the others revealed the dynamic nature of this phenomenon, and necessitate performing the periodic studies in these areas. Moreover, cytogenetic and immunologic researches for studying the long term effects of these high level environmental radiations on the residents of these HLEBRAs are necessary.
Keywords: Annual Effective Dose, External Environmental Radiation, Gamma Radiation, High Background Radiation, Ramsar

1- Biochemistry and Biophysics Dept., Faculty of Medicine, Mazandaran University of Medical Sciences, Sari, Iran
*Corresponding author: Tel: +98 151 3543081, +98 914 346 0109; email: tpourfallah@mazums.ac.ir
2- Nuclear Engineering Dept., Azad Islamic University, Sciences and Researches Unit, Tehran, Iran.

1. Introduction

According to the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) report [1], the worldwide average annual exposure to natural radiation sources is 2.4 mSv [2, 3].

In most places on the earth, the natural radioactivity varies only within narrow limits, but in some places there are wide deviations from normal levels because of abnormally high levels of radioactive minerals [3].

External irradiation from radionuclides naturally present in the environment or released from man-made practices or events is usually an important component of the exposure in human populations. These exposures derive primarily from gamma radiation arising from the decay of radionuclides at locations outside the human body. Secondarily, exposures to the skin from beta radiation may be considered [3].

Cosmic rays originate in outer space; they consist primarily of protons and alpha particles. Interactions in the upper layers of the earth's atmosphere create secondary components; the more important secondary particles from a dose-assessment view are muons, neutrons, electrons, positrons, and photons. Exposure to cosmic rays is strongly dependent on altitude and weakly dependent on latitude [3].

Many radionuclides occur naturally in terrestrial soils and rocks and in building materials derived from them. Upon decay, these radionuclides produce an external radiation field to which all human beings are exposed. In terms of dose, the principal primordial radionuclides are 40K, 232Th, and 238U.

Following the release of these radionuclides to the atmosphere and before their deposition into the ground, human beings may receive external exposure. However, because of their relative insignificance, the UNSCEAR has seldom considered external exposures from immersion and except for the immediate site of the explosion, external irradiation from airborne material is negligible in comparison with external irradiation from fission products deposited on the ground [3].

The results of some radiological studies in Ramsar, a beautiful northern city in Iran overlooking the Caspian Sea, and its high level environmental background radiation areas (HLEBRAs) which were carried out over a decade ago on public doses and health-related and biological effects were previously reported [4-10]. However, due to the dynamic nature of such areas, more detailed periodic studies for possible epidemiological variations are needed.

Ramsar has more than 50 hot springs, and some of them are used as spas by the public and vacationers. Its HLEBRAs are dynamic and are formed by the water from the springs containing a high ^{226}Ra concentration such as 146 kBq m-3 which flow into the surrounding areas [8, 11]. Such a dynamic situation indicates that for any meaningful health-related study in such areas, public effective doses from external and internal exposures, indoors, and outdoors, should be retrospectively and precisely known.

The purpose of this study was to identify the possible new areas in Ramsar with HLEBR and also reveal dynamic nature of these areas with regard to previously published reports.

2. Materials and Methods

The study was carried out in Ramsar in more than 90 points in five districts with HLEBRAs around and near hot springs. For measuring the equivalent dose of exposure to external radiation in μSv/h, the POSHUK dosimeter (ECOTEST company, Ukraine) with a sensitivity of 0.1 μSv/h and ± (25+2/p) deviation (i.e., p is the measured equivalent dose rate) in the research mode was used. The dosimeter had reliable calibration in the time of measurement. The geographical location in each measurement was recorded using a GPS (geographical positioning system) device (Garmin Oregon, model 550, Taiwan) with 1-3 m accuracy.

The measurements were performed in every 20 m^2 extent allotment of the region of HLEBRAs. The number of samples (i.e., allotments) was dictated by the wastness of each allotment. The dose rate was measured directly in the field at one meter above ground level (absorbed dose rate in air) in these allotments.

The mentioned small areas in HLEBRAs mostly were near the spas. All measurements were performed outdoor and for converting absorbed dose in air to equivalent dose, a coefficient of 0.7 Sv Gy^{-1} was used [12]:

Annual effective dose (mSv/y) = Equivalent dose rate (μSv/h) × 0.001(μSv/mSv) × 8760h × 0.2 (occupational factor)

The selected region of HLEBRAs were chosen according to reports from other researches [4-11, 13-17], however, measurements were also performed near a hot spring at Sadat-Mahaleh district (Figure 1, region E).

All measurements were carried out on July 2011. The average temperature, humidity, and pressure in the region were 37 °C, 47.5%, and 1002 mbar, respectively. The average altitude in HLEBRAs and seashore are +15.8±8.5 m and -14±3.6 m, respectively.

3. Results

The measured and calculated quantities including maximum doses from background radiation in different regions of Ramsar as well as precise locations of measurements are shown in Table 1.

The geographical locations of the regions are also showed in Figure 1. Maximum level annual effective dose was acquired in the Shahrake-Golha and Sadat-Mahaleh. In some spots of this region exposure to natural external radiation exceeded the natural limits defined for radiation workers (20mSv/h). Exposure levels near the seashore (that can be considered as normal background radiation) were nearly 200 times lower than those measured in the HLEBRAs.

Maximum radiation level due to cosmic rays as measured on sea level was equal to 0.04±%75, not significant compared with the values acquired at the HLEBRAs.

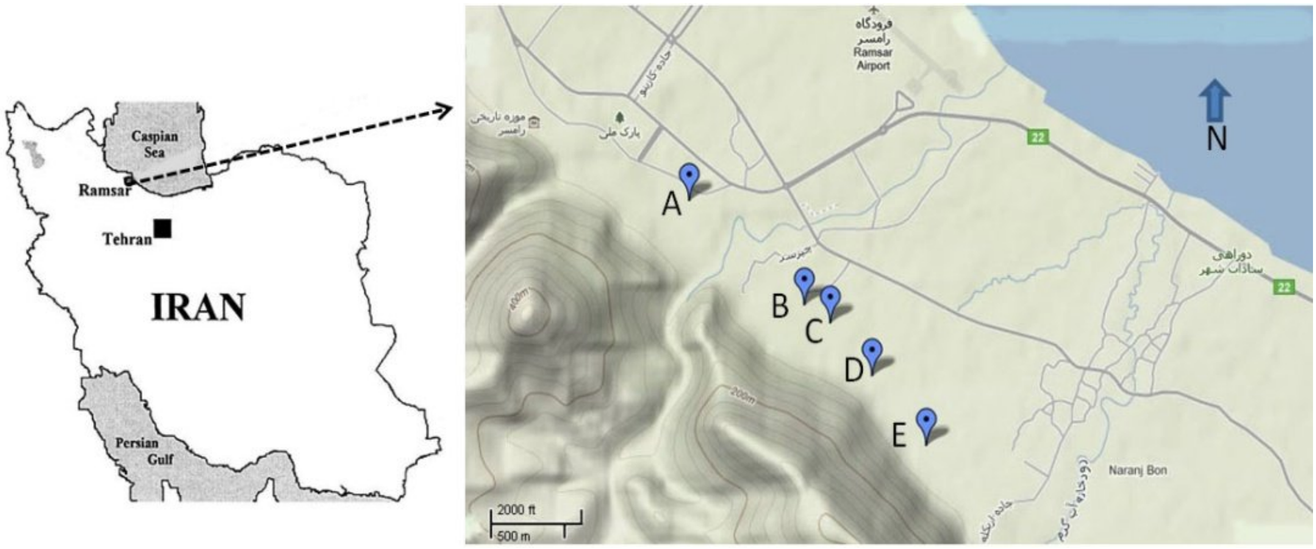

Figure 1. Geographical map of the Ramsar with its HLEBRAs. A, B, C, D, and E points corrospond to the Ramak and abe-Siyah, Chaparsar, Talesh-Mahaleh, Khake-Sefid, Sadat-Mahaleh, and Shahrake-Golha regions.

Table 1. Maximum and mean equivalent dose rates and annual effective doses in HLEBRAs in Ramsar, seashore, and one km from the seashore. A, B, C, D, and E points are also depicted in Figure 1.

Regions	Max. Dose Rate (μSv/h)	Mean Dose Rate (μSv/h)	Max. Effective Dose (mSv/y)	Mean Effective Dose (mSv/y)	No. of allotments in each Region	Longitude & latitude (Degrees)
Ramak & Abe-Siyah (A)	3.29±25.61%	1.94±28.71%	5.76±25.61%	3.40±28.71%	9	50.6659 & 36.8987
Chaparsar (B)	9.28±25.2%	4.03±26.0%	16.26±25.2%	7.07±26.0%	10	50.6747 & 36.8927
Talesh-Mahaleh (C)	8.3±25.24%	2.51±27.69%	14.54±25.24%	4.39±27.69%	18	50.6766 & 36.8917
Khake-Sefid (D)	10.7±25.19%	4.97±25.60%	18.7±25.19%	8.70±25.60%	26	50.6798 & 36.8917
Sadat-Mahaleh & Shahrake-Golha (E)	22.72±25.1%	6.63±26.1%	39.80±25.1%	11.61±26.1%	24	50.6839 & 36.8847
Seashore	0.1±47.22%	0.08±49.58%	0.19±25.1%	0.15±49.58%	3	50.7483 & 36.8825
One km from seashore	0.04±75%	0.03±97.22%	0.07±75%	0.07±97.22%	3	50.7558 & 36.8885

4. Discussion

In this study, the obtained dose values were due to effective dose of external environmental background radiation. It is clear that by taking into account the effective dose due to internal radiation, the combined annual effective dose will be much higher than the current values. According to UNSCEAR [1] report, radon and its progeny are responsible for half of the total annual effective dose of natural background radiation and it was shown that the mean effective dose resulting from ^{226}Ra due to consumption of edible vegetables by adults in the critical group in this region (Ramsar) was estimated to be 72.3 μSva^{-1}. This value is about 12 times greater than of the average effective dose resulting from this radionuclide due to combined intake of all foods and drinking water in normal background areas[16].

By considering the results of this study and other studies, some differences, both in location and dose values were observed. In our study although the Sadat-mahaleh and Shahrake golha showed in average the biggest dose values and with maximum value equal to 39.80±25.1% mSv/y. However, it was much lower than dose values in Khake-Sefid as the hottest point in another study [17], in which the potential annual effective doses of the public in HLEBRAs range from 0.6 to 131 mSv with a mean value of 6 mSv, and in LLNRAs (Low Level Natural Radiation Areas) range from 0.6 to 1.5 mSv with a mean value of 0.7 mSv were observed.

In another study [9], the minimum and maximum values of ^{226}Ra concentration (1.1 Bq l^{-1} and 146.5 Bq l^{-1}) were measured in the Sadat Mahalleh and Abe-Siah hot springs, respectively. These hot springs were responsible for the distribution of ^{226}Ra and the creation of HLEBRAs in Ramsar and these results also differ from ours.

Regardless of observed differences that can be due to dynamic nature of the spas and environmental variations in the region, more systematic studies are necessary to reveal the long term cytogenetic and immunologic effects of these high level radiations on the residents in the region. For example, results of a study [15] showed a significant increase of CD69 expression on TCD4+ stimulated cells ($p<0.004$) and a significant increase in total serum IgE ($p<0.05$), and also higher incidence of stable and unstable chromosomal aberrations in the HLNRA group compared with the control group with normal background radiation ($p<0.05$). In another study [13], radiosensitivity or adaptive responses, on the inhabitants of high natural radiation in Ramsar were evaluated and it was found that the spontaneous level of DNA damage and the induced DNA damage in all challenging doses in case group was considerably higher than control groups ($p<0.05$).

5. Conclusion

This study revealed that the annual effective dose per capita in the HLEBRAs in Ramsar is in average 77 and in some points 209 times higher than of those observed in the LLEBRAs. Since the radon and its progeny are principle components to annual effective doses in HLEBRAs, periodic studies for evaluation of their role in internal radiation in these regions are essential.

It seems that the observed differences between the results of this study and other studies are due to the dynamic nature of such areas and more detailed periodic studies are needed.

Studies on the long-term effects of high level natural radioactivity on some immunological and cytogenetical parameters in Ramsar inhabitants are also necessary.

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