Gonad, bone marrow and effective dose to the population of more than 90 towns and cities of Iran, arising from environmental gamma radiation

M.T. Bahreyni Toossi[1*], SH. Bayani[1], M. Yarahmadi[2], A. Aghamir[3], A. Jomehzadeh[4], M. Hagh Parast[5], A. Tamjidi[6]

[1]Medical Physics Research Center, Mashhad University of Medical Sciences, Mashhad, Iran
[2]Medical School, Kurdistan University of Medical Sciences, Sanandaj, Iran
[3]Razavi Hospital, Mashhad, Iran
[4]Rafsanjan University of Medical Sciences, Rafsanjan, Iran
[5]Hormozgan University of Medical Sciences, Bandarabbas, Iran
[6]Bushehr Port University of Medical Sciences, Bushehr, Iran

Background: Since 1996 the assessment of environmental gamma radiation dose in residential areas of Iranian towns and cities has been accomplished for 10 counties. As a practical method and based on the results of a pilot study, in order to attribute the final results to the whole residential area of a town five stations were selected for every town. The location of individual station was studied closely to comply with recommended conditions in the literature. *Materials and Methods:* RDS-110 was employed to measure gamma dose rate for one hour. Average annual dose rates plus conversion coefficients were employed to estimate gonad, bone marrow, equivalent and effective dose. *Result:* Minimum and maximum annual bone marrow and gonad dose equivalent attributed to environmental gamma are 0.24 mSvy^{-1} (for both tissues) and 1.44 and 1.46 mSvy^{-1}, respectively. *Conclusion:* Average gonad and bone marrow doses for North Khorasan, Boshehr and Hormozgan provinces were less than the corresponding values for normal area. **Iran. J. Radiat. Res., 2009; 7 (1): 41-47**

Keywords: *Gonad, bone marrow, effective dose, environmental, gamma radiation.*

INTRODUCTION

Environmental gamma radiation level is varying widely for different locations and is influenced by several factors. Geological and geographical factors are two main intrinsic elements affecting radiation level at different localities [(1)]. Exposure to human beings from environmental sources as a whole and exposure from various natural and man-made sources have been extensively studied in developed and developing countries. Until 1996 there have been no strategies for comprehensive studies of environmental radiation level in Iran. Only sporadic and limited (in terms of time and distance) measurements had been conducted [(2, 3)]. In 1996 a comprehensive assessment of gamma dose rates to the general population of residential areas of Iran was defined as a long term goal in medical physics research centers. It is hoped that eventually preparation of annual in-door and out-door dose rate map of the whole country will be accomplished. Till now measurements have been carried out for 10 counties, covering an area comprising over 33% of the whole country. The followings are summaries of activities carried out over the past 10 years over a vast area exceeding 550,000 km^2, with an approximate population of 15,220,000. As a part of this study, in 1997, Bahreyni Toossi and *et al.* reported annual gamma dose rate for Mashhad and at the surface of all mineral and hot sources of Khorasan region [(4)]. In 1999 Bahreyni Toossi, *et al.* studied environmental gamma dose level for Tabriz, Orumieh and Sarein (including the town &

Corresponding author:
Dr. Mohammad Taghi Bahreyni Toossi,
Medical Physics Research Center, Mashad University of Medical Sciences, Bu-Ali Square, Mashad, Iran.
Fax: *+98 511 8002320*
E-mail: *bahreynimt@mums.ac.ir*

all seven hot sources) [5]. In 2001, Bahreyni Toossi et *al.* reported environmental gamma dose rates for 24 cities of the greater Khorasan province [6] and Yarahmadi *et al.* collected similar information for 8 cities of Kurdistan province [7]. In 2003, Aghamir et *al.* carried out a similar study for all cities, towns and at the surface of all mineral and hot sources of Mazandaran including Ramsar [8]. In 2003, Jomezadeh and Bahreyni Toossi succeeded to measure in-door and out-door dose rate for all towns in Kerman province [9]. In 2004, Haghparast and Bahreyni Toossi reported their results for two counties in east and south east of Iran, they worked in Gachin area more extensively [10]. Environmental gamma dose level in air has also been reported for Bousher County in 2004 by Tamjidi *et al.* [11].

Although the harmful effects of very low doses of ionizing radiation is a controversial issue, it is known that radiation in different doses and times of exposition can induce many responses in living organisms. In this context, it was intended to find out the dose levels received by sensitive body organs from the environment.

In this article annual environmental gamma doses measured for 10 provices in Iran have been utilized to compute: annual effective dose, bone marrow and gonadal dose and population weighted dose of general population.

MATERIALS AND METHODS

Sampling location must be representative of the city to be measured. As a practical method, five stations were selected for each town. The location of individual station was studied closely to comply with the recommended conditions in the literature [12]. By means of a map, the first station was selected at a suitable place in the city center. The other four stations were selected, at the border line of the town residential area and along with the four main geographical directions.

A "multi purpose survey meter RDS-110" (RADOS Inc., Finland) was recognized as the detector of the choice for environmental measurements [6]. It was employed from the beginning to the end our study. RDS-110 is capable of recording dose rates as low as 0.05 μSv/h up to a maximum of 100 mSv/h.

Throughout the survey, dose rate measurements were performed in the following order:

Five locations were marked on the latest edition of every town's map.

A survey meter model RDS-110 was placed on an aluminum frame and a tripod one meter above the ground level, horizontally and in the south-north direction.

All displayed dose rates on display of the detector were recorded for one hour, this procedure was repeated in three successive days.

Mean of all recorded data was computed and taken as dose rate of that particular station.

Dose rates acquired were statistically tested to find out if they were significantly different from corresponding values obtained for the other four stations, to decide whether further investigation was necessary.

Computed mean of all five stations in every town was chosen as average dose rate for the specified town.

Calculated mean dose rate for every town in combination with the relevant coefficients suggested by UNSCEAR [13] for outdoor exposure were employed to compute bone marrow, gonadal and effective dose of general population.

Mean dose rate and population of all towns located in a particular county were utilized to calculate population weighted mean dose for that county.

RESULTS AND DISCUSSION

Average annual dose rates were calculated for more than ninety towns and cities, and the data was considerable. In practice, it was not possible to tabulate them on one table, so they are graphically presented in figure 1. Also, the mean, minimum and maximum values of all dosimetric quantities of interest for all 10 provinces, included in the survey, were summaried and presented in table 1.

In total, 450 gross measurements (in 90 towns, 5 stations per town) on environmental gamma absorbed dose in air were made in 10 counties. A large volume of data was collected, and summarized in (table 1). Detailed presentation of all data collected in a study such as the present work is not practical; however, summarizing data to this extent would disguise the exact variations of dose rate among different locations in a specified town or province. The recorded figures in column one of table 1 are representative of environmental gamma absorbed dose rate trend in air in the regions of interest in this radiological surveillance. It is evident that maximum dose rate (205 nSv/h) has been obtained for Reaneh in Mazandaran, and the minimum value (35 nSv/h) has been for Minab in Hormozgan provinces.

As gonad and bone marrow doses are directly proportional to absorbed dose in air therefore it is a consistent conclusion to say that resident of Reaneh receive the highest gonad and bone marrow dose (1.44 & 1.46 mSvy^{-1}), while the corresponding quantities for people living in Minab will be minimum (0.24 and 0.24 mSvy^{-1}).

Population weighted annual absorbed dose for all 10 province included in this work, are also presented in figure 2. It is evident that maximum Population weighted annual absorbed dose (1 mSv/year) has been obtained for Kurdistan, and the minimum value (0.35 mSv/year) has been related to Hormozgan.

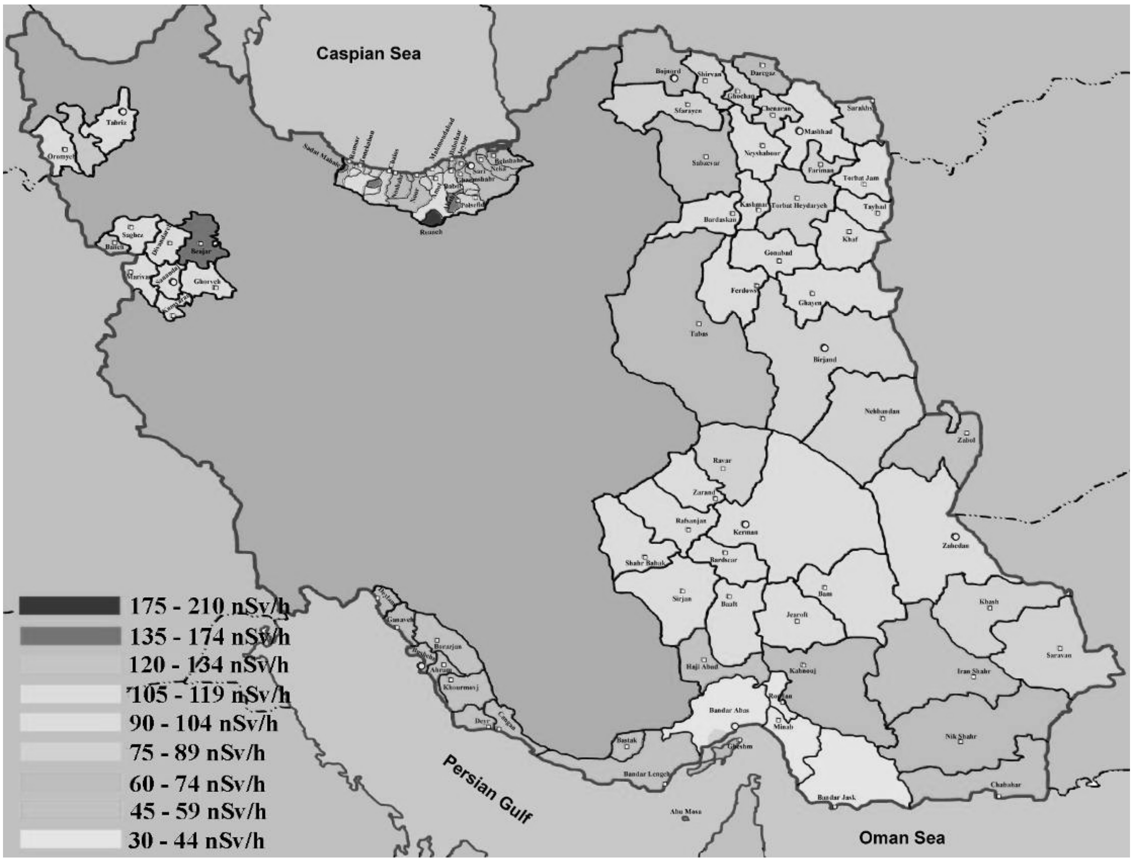

Figure 1. Partial map of environmental gamma dose-rate (out-door) for more than ninety towns and cities of Iran.

Table 1. Dosimetric quantities arising from environmental gamma radiation in 10 counties of Iran.

Province / Dosimetric quantities		Absorbed dose rate (nGy/h)	Equiva-lent dose (mSv/y)	Effective dose (mSv/y)	Red bone marrow dose (mSv/y)	Gonads Dose (mSv/y)
Azarbayjan (Tabriz, Oromieh and Sarein)	Minimum	111.8	1.07	0.86	0.98	0.99
	Mean	112.9	1.09	0.88	1.00	1.01
	Maximum	114.0	1.11	0.90	1.02	1.03
Boushehr	Minimum	47.2	0.36	0.29	0.33	0.33
	Mean	56.3	0.43	0.35	0.39	0.40
	Maximum	61.8	0.47	0.38	0.43	0.44
Hormozgan	Minimum	34.6	0.26	0.21	0.24	0.24
	Mean	49.4	0.38	0.30	0.34	0.34
	Maximum	78.9	0.60	0.48	0.55	0.56
Kerman	Minimum	69.6	0.53	0.43	0.49	0.49
	Mean	96.8	0.73	0.59	0.68	0.68
	Maximum	118.2	0.90	0.72	0.82	0.83
Khorasan South	Minimum	85.0	0.78	0.63	0.72	0.73
	Mean	85.5	0.84	0.68	0.77	0.78
	Maximum	86.0	0.89	0.72	0.82	0.83
Khorasan Razavi	Minimum	62.0	0.62	0.50	0.57	0.57
	Mean	90.5	0.87	0.70	0.80	0.81
	Maximum	120.0	1.14	0.92	1.05	1.06
Khorasan North	Minimum	70.0	0.79	0.64	0.73	0.74
	Mean	79.0	0.85	0.68	0.78	0.79
	Maximum	84.0	0.90	0.72	0.83	0.84
Kordestan	Minimum	91.8	0.70	0.57	0.65	0.66
	Mean	115.5	0.88	0.69	0.79	0.80
	Maximum	144.1	1.10	0.83	0.94	0.96
Mazandaran	Minimum	68.0	0.52	0.43	0.48	0.49
	Mean	91.3	0.70	0.56	0.64	0.65
	Maximum	205.0	1.56	1.26	1.44	1.46
Sistan and Blochestan	Minimum	48.3	0.37	0.29	0.34	0.34
	Mean	66.9	0.51	0.41	0.47	0.47
	Maximum	90.4	0.69	0.55	0.63	0.64

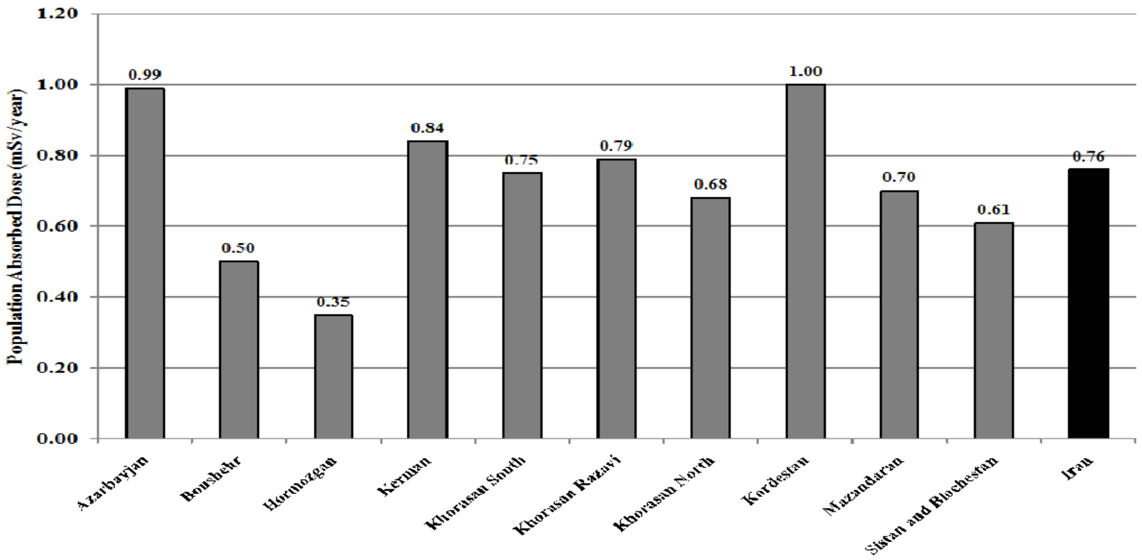

Figure 2. Population weighted annual absorbed dose arising from environmental gamma radiation in 10 counties of Iran.

CONCLUSION

Altitudes of towns under comprised a very wide range. The towns were located at different altitudes, ranging from -25 to 2100 m from sea level. Figure 3 shows the variation of equivalent dose, effective dose, red bone marrow and gonadal dose with altitude. It can also observed that with a good approximation average dose rate in air and all other derived dosimetric quantities, were a linear function of altitude.

Dose rates were also examined against latitude. Figure 4 shows the equivalent dose, effective dose, red bone marrow and gonadal dose are increasing with latitude; this could be true up to 35° north. From figure 4 it is evident that the average dose rate had increased moving to higher latitudes; however, at 35° north, the upward trend had declined. Further, the examination of the acquired data revealed that the towns located beyond 35° north were in northern Khorasan or in Mazandaran

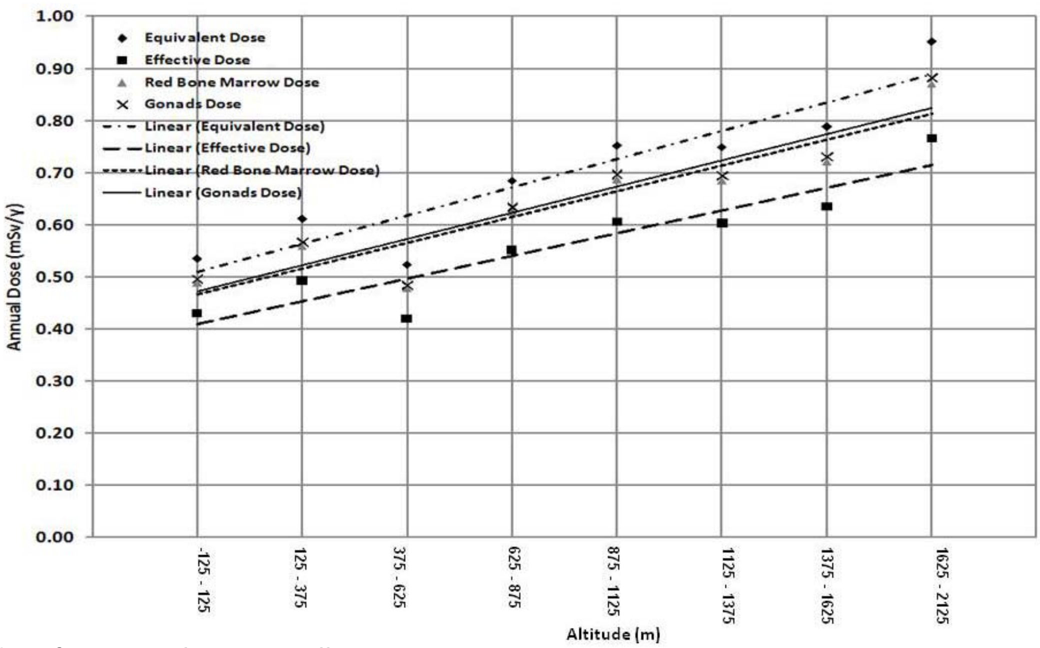

Figure 3. Variation of equivalent, effective, red bone marrow and gonadal annual dose with altitude in this study.

province. As a matter of fact many towns in Mazandaran were located at low altitudes or approximately at sea level, which could have been a reason for lower average dose rates in those areas.

Finally in figure 5 the average dosimetric quantities obtained for Iran (the regions included in this work) are compared with similar data reported for Germany, Hong Kong, United Kingdom, and the United States, normal area as well as world mean values [14]. The average outdoor dose rate for the regions in Iran was equal to normal area value and greater than World mean value.

AKNOWLEDGEMENT

The authors would like to thank the office of Vice President for Research, Mashhad University of Medical Sciences for financial support of this work.

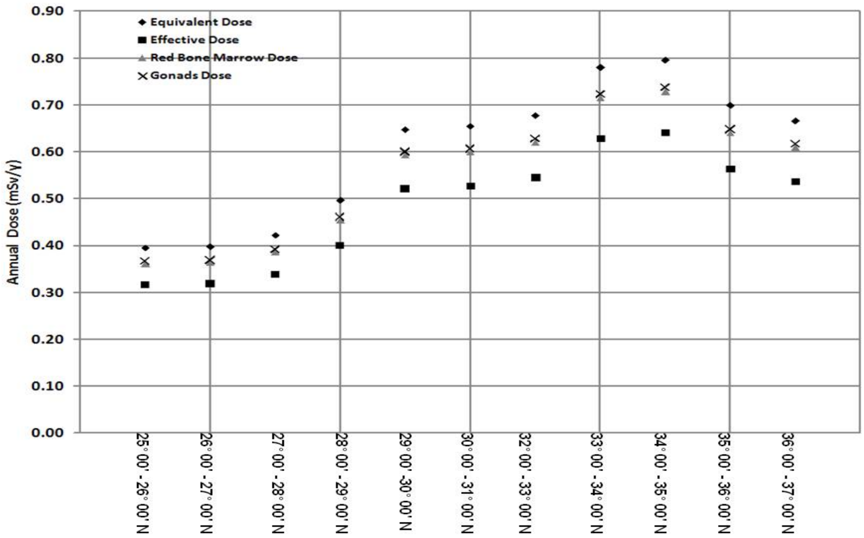

Figure 4. Variation of equivalent, effective, red bone marrow and gonadal dose with latitude in this study.

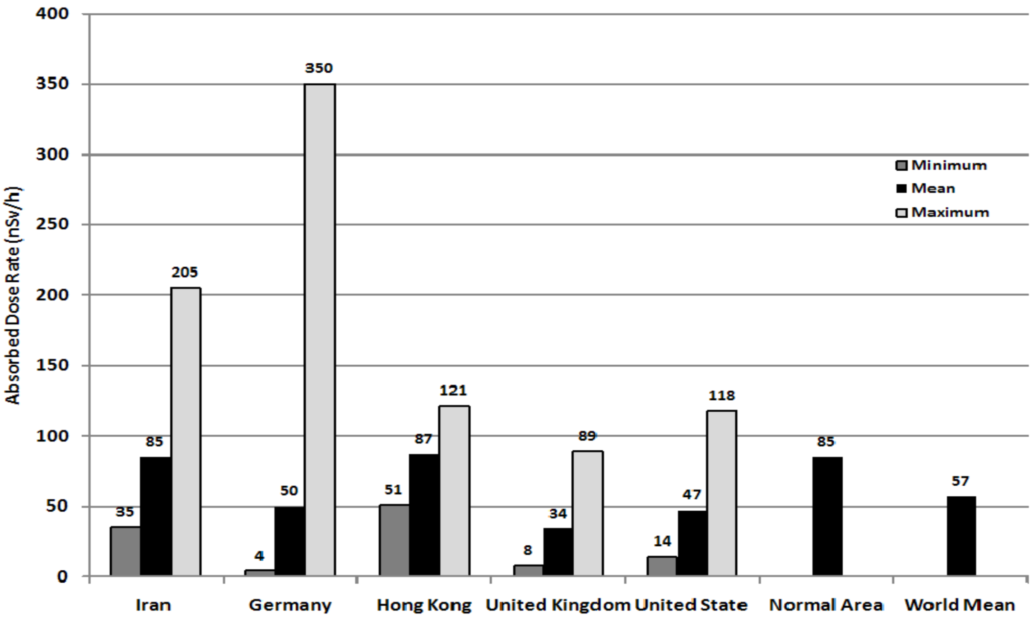

Figure 5. Minimum, maximum and mean dose rate (outdoor) of residential areas of Iran(so far obtained in this work) is compared with the corresponding quantities for some other countries.

REFERENCES

1. Bastos RO and Pascholati EM (2005)Environmental gamma radiation in municipalities of Eastern of São Paulo State, Brazil. Terrae, Environment & Health, ***1-2:** 37-45*.
2. Khademi B, Sekhavat A, Parnianpour H (1977) Area of high natural background radiation in the northern part of Iran. Proceeding of International Symposium on Areas of High Natural Radioactivity. Pocos de Caldas, Brazil, June 1975. Pontifı´cia Universidade Cato´lica, Brazil, 186.
3. Ghiassi-nejad M, Mortazavi SMJ , Cameron JR (2002) Very high background radiation areas of Ramsar, Iran: preliminary biological studies. *Health Phys,* ***82:** 87-93.*
4. Bahreyni Toossi MT, Oroogi MH (1999) An investigation of environmental gamma radiation rate in Mashhad and Rural area. *Iranian Journal of Basic Medical Sciences,* ***2:** 117-123.*
5. Bahreyni Toossi MT and Sadeghzadeh A (2000) Estimation of Environmental Gamma Background Radiation Levels in Azarbayjan. *Iranian Journal of Basic Medical Sciences,* ***3:**17-24.*
6. Bahreyni Toossi MT and Abdolrahimi MR (2007) First report of environmental gamma radiation levels in twenty four towns and cities of Khorasan region-Iran. The fourth ITRS International Symposium on Radiation Safety and Detection Technology, ISORD-4. Seoul, Korea.
7. Yarahmadi M and Bahreyni Toossi MT (2004) Comparison indoor and outdoor dose rates from environmental radiation in Kurdstan province's towns. The 6th Iranian Congress of Medical Physics, Mashhad, Iran.
8. Aghami A and Bahreyni Toossi MT (2004) An assessment of exposure from environmental gamma radiation in cities and hot and mineral spring waters of Mazandaran province, The 6th Iranian Congress of Medical Physics, Mashhad, Iran.
9. Bahreyni Toossi MT and Jomehzadeh A (2005) Comparison of environmental gamma radiation of Kerman province and indoor gamma dose rate in Kerman city using thermoluminent dosimeter (TLD) and RDS-110. *Quarterly Journal of Hormozgan University of Medical Sciences,* ***9:** 173-180*.
10. Bahreyni Toossi MT and Hagh Parast M (2006) Gachin dwellings on a hot area but with normal background. IRPA- 2006. Paris, France.
11. Tamjidi A and Bahreyni Toossi MT (2004) An assessment of annual effective dose and sensitive organ dose from environmental gamma radiation in cities of Boushehr province. The 6th Iranian Congress of Medical Physics, Mashhad, Iran,.
12. Spiers FW, Gibson JAB, Thompson IMG (1981) A guide the measurement of environmental gamma ray dose rate. (London: British Committee on Radiation Units and Measurements).
13. United Nations Scientific Committee on the Effects of Atomic Radiation. (1993) Sources and effects of ionizing radiation. UNSCEAR, 1993 report.
14. United Nations Scientific on the Effects of Atomic Radiation. (2000) Sources and effects of ionizing radiation. UNSCEAR report to general assembly. New York: UN; 2000, Vol 1.