Monitoring the Environmental Radiation Levels for Some Regions in Iraq

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ABSTRACT

The absorbed dose rates in air have been monitored in 23 different urban areas in Iraq using TLD dosimeter for the period 1992-1994 and in 2011-2012, with no significant differences observed. The risk of cancer incidence (morbidity) and mortality to the individuals related to external exposure to ambient gamma radiation is evaluated in this study using the linear, no-threshold (LNT) dose-response model. The risk estimations include delayed radiation effects (cancer morbidity, mortality and hereditary genetic damages). The mean effective dose equivalent to the individuals of 0.48 mSv/y is found to be less than the recommended dose limit to the public established by the International Atomic Energy Agency of 1 mSv/y. However, the findings of this study report that about 0.24% of the respective population are expected to be diagnosed with radiation-induced cancer over there lifetime. The lifetime fatal cancer probability (mortality) is estimated to be occurs at a rate of 0.18%. The risk of developing fatal stomach cancer is found to be occurs at a largest extent in comparison with other exposed body organs and tissues. Other consequences of radiation injury such as genetic effects transmitted to succeeding generations are expected to occur at a rate of 0.03% in the offspring of the respective population as a result of changes transmitted via the genetic mechanisms due to irradiation of gonads.

Key words: Environmental Radiation

1. INTRODUCTION

The surroundings in which one lives or works constitute the environment. There is, of course, the natural environmental radiation always and everywhere present but this is not of particular concern as far as the heath and safety of the inhabitants is concerned. Increased radioactivity arising from atomic explosions, nuclear tests, and nuclear reactor leakage and accidents can considerably increase the level of environmental radiation, which evidently requires to be monitored [1]. The aims of this study are:-

(1) Monitoring of the ambient gamma-radiation doses to which people are exposed.

(2) Make quantitative estimations of the biologically damaging effects associated with exposure of inhabitants to radiation levels using a hypothetical linear, no-threshold (LNT) dose-response model.

2. MATERIALS AND METHODS

The gamma ray dosimetry in µRad/hr were measured using Thermo Luminescence Dosimeter (TLD) type CaSo4:Dy (Vinten system), which is a highly suitable TLD because of its very low threshold and tolerance fading, thus enabling dose rates measurements at background radiation levels [1]. The absorbed dose rates in air have been sampled for 3 months, for the period from 1992 to 1994 and in 2005. The monitoring locations cover 23 urban areas in Iraq.

A coefficient of 0.7 Sv/Gy is used to convert absorbed dose rate in air to effective dose equivalent. UNSCEAR 1993 report provides coefficients for exposure to terrestrial gamma rays for adults (0.72 Sv/Gy), children (0.80 Sv/Gy) and for infants (0.93 Sv/Gy) [2].

3. HEALTH RISK ASSESSMENT:

Risk, may be defined as the chance of encountering the potential adverse effects of human or ecological exposures to environmental hazards. In general terms, risk is the probability of harm or loss, which may also be considered as a product of probability and the severity of consequences [3].

Four steps have been defined by both the National Academy of Sciences and the EPA for the assessment of risk from hazardous wastes [4]:

(1) Hazard identification: the chemicals present at the site and their characteristics; i.e., source analysis.

(2) Exposure assessment: potential transport of the chemicals to receptors and levels of intake; i.e., pathway analysis.

(3) Toxicity assessment: including the determination of numerical indices of toxicity; i.e., receptor analysis.

(4) Risk characterization: involving the determination of a number that expresses the risk, such as one in one hundred (0.01), or one in one million ($1*10^{-6}$).

Observed radiation affects (or effects the other types of noxious agents) may be broadly classified into two categories, stochastic and non-stochastic effects. In the context of radiation protection, the main stochastic effects are cancer and genetic effects. The results of exposure to a carcinogen or to a mutagen are an increase in the probability of occurrence of the effect with the increase in probability being directly proportional to the size of the dose [5]. Radiation doses to exposed population are estimated by using equation below:

$$\text{Radiation dose rate}\,(\overline{H}_i)\left(\frac{mSv}{y}\right)\text{for adults}=\text{Exposure rate}\left(\frac{\mu R}{hr}\right)*10^{-3}\times 0.87\left(\frac{rad}{R}\right)\times 0.01\left(\frac{Gy}{rad}\right)\times 0.7\left(\frac{Sv}{Gy}\right)\times 24\left(\frac{hr}{day}\right)\times 365\left(\frac{day}{y}\right) \quad \ldots (1)$$

The final step in a risk assessment is to bring the various studies together into an overall risk characterization [6]. Public health risk for individual members is modeled in this study as a linear function of radiological dose:

$$\text{Risk} = \text{Dose}\left(\frac{mSv}{y}\right)\times 10^{-3}\left(\frac{Sv}{mSv}\right)\times \text{Lifetime (y)}\times \text{Risk Factor}\left(\frac{Risk}{Sv}\right)\ldots (5)$$

where Risk = the probability of carcinogenic risk (dimensionless), lifetime exposure is taken to be 70 years (standard exposure duration for an adult exposed to a carcinogen)[6].

Estimation of the potential risk from low levels of ionizing radiation requires application of dose-to-risk conversion factors to an estimate of the dose. For external sources of linear energy transfer (LET) radiation that provide nearly uniform irradiation of the body, the risk of cancer incidence (morbidity) and mortality as a function of external dose can be closely approximated using the conversion factors of $8*10^{-2}$ and $6*10^{-2}$ risk per sievert (Sv), respectively [7]. Morbidity and mortality risks to specific body organs and tissues can be estimated by means of the risks factors listed in Table (1) [8]. Lethality is that fraction of cancer incidence that results in fatality, while survivability is that fraction of cancer incidence that does not result in a fatality (Survivability=1–Lethality). The risk coefficient for genetic effects in all generations following the radiation exposure of adults is 0.01 Sv^{-1}[9].

Table (1): Risk factors to various body organs and tissues (Sv=100 rem):

Cancer	Radiation mortality (risk per rem)	Radiation incidence (risk per rem)	Lethality	Survivability
Bladder	0.00003	0.00006	0.5	0.5
Bone surface	0.000005	0.00001	0.7	0.3
Breast	0.00002	0.00004	0.5	0.5
Colon	0.000085	0.00015	0.55	0.45
Leukemia (Bone marrow)	0.00005	0.00005	0.99	0.01
Liver	0.000015	0.00002	0.95	0.05
Lung and Bronchus	0.000085	0.00009	0.95	0.05
Oesophagus	0.00003	0.00003	0.95	0.05
Ovary	0.00001	0.00001	0.7	0.3
Skin	0.000002	0.001	0.002	0.998
Stomach	0.00011	0.00012	0.9	0.1
Thyriod	0.000008	0.00008	0.1	0.9
Remainder	0.00005	-	-	-

The genetic injury or damage from radiation exposure is estimated in this study from the total number of human-sieverts delivered to the gonads. It is thought that in the majority of cases the inherited change will have a deleterious effect on the individual. This may be premature death, inability to produce offspring, susceptibility to disease, or any number of changes of lesser or greater importance. The genetic risk coefficient for gonads is taken to be 4×10^{-3} Sv^{-1} for the first 2 generations and 0.01 Sv^{-1} for all generations [5,9,10].

4. RESULTS AND DISCUSSION

Multi-step risk assessment process is used in this study to predict the biologically damaging effect of public exposure to ambient radiation levels. The 1st step is making quantitative measurements of the absorbed dose rates using TLD dosimeters and the results are expressed in µRad/hr. The 2nd step is estimation of the biological dose in human tissues and organs (in mSv/y) for local inhabitants using a series of conversion factors available in the literature. The last step is making a correlation between the dose administered and the radiation injury produced using a linear, no-threshold (LNT) dose-response statistical model.

The environmental γ-radiation level measurements were carried out outdoors within 23 urban areas in different regions of Iraq. The results are presented in Table (2). Step-by-step computation of the effective dose equivalent from the absorbed dose rates is shown in Table (3). The observed absorbed dose rates in air in µR/hr cover a somewhat narrow range owing to the fact that the investigated areas are less variable in their radioactive content. The whole-body effective dose equivalent inferred from measurement (0.503 mSv/y) is found to be greater than the annual effective dose equivalent of 0.01 mSv, which corresponds to the National Council on Radiation Protection and Measurement (NCRP) concept of negligible individual risk level. This result indicates that public exposure to natural background radiation causes considerable possible long term bioeffects include increased incidence of somatic and hereditary genetic effects (increased incidence of genetic abnormalities in humans) to a large number of individuals in Baghdad population.

The likelihood or probability of radiation risk to Baghdad population is evaluated in Table (4) using a linear, no-threshold (LNT) dose-response model (Eq.(5)) and the risk factors listed in Table (1). The biological effects of natural background radiation are expressed in statistical terms due to biological variability accounts for a difference in sensitivity among individuals and a wide variation in susceptibility to radiation damage exists among different types of cells and tissues. The probabilities of cancer risks to various body organs and tissues are calculated and the results are listed in Table (4). The results of quantitative risk assessment are written in Table (4). The risk of developing blood cancer (leukemia) as a result of the irradiation of the bone marrow is calculated to be 1 in a group of 6802 exposed individuals, while the risk of developing bone cancer is evaluated to be 1 in 34013. The fatality rate for the populations of interest owing to natural γ-radiation exposure is evaluated at 25.7 extra fatal cancer case/million people/year. If the entire breeding respective population received a radiation dose of 0.48 $mSv.y^{-1}$ from external exposure to ambient gamma radiation, then the probability of having hereditary genetic damage (increasing the mutation rate in chromosomes and genes, affects future generations) is estimated to be occurs at a rate of about 1 per 2976 or 336 per million in parents who were irradiated before conception occurred. The gonad dose of 0.48 mSv/y is found to be less than the population dose limit for genetic effects of 1.7 mSv/y proposed by the National Council on Radiation Protection and Measurements (NCRP) [11] and less than the dose limits for gonads of 5 mSv/y recommended by the International Commission on Radiological Protection (ICRP) [5].

Table (2): Absorbed dose rates in air inferred from direct measurements for the period (1992-1994 and 2011-2012):

No.	Measurement location	Absorbed dose rate in air (µRad/hr)			
		1992	1993	1994	2011-2012
1	Baghdad (metrological station in airport)	7.29	7.02	7.17	NA
2	Baghdad (Al-Twaitha)	7.5	7.5	7.47	7.14
3	Al-Basrah (metrological station)	6.42	6.57	6.34	7.05
4	Al-Emara (metrological station)	6.04	*NA	5.78	6.32
5	Thi-Qar (metrological station)	6.69	6.10	6.52	6.85
6	Wasset (metrological station)	NA	6.29	6.57	6.72
7	Al-Hilla (metrological station)	6.62	6.70	6.55	6.85
8	Al-Najaf (metrological station)	6.57	6.50	6.62	6.73
9	Karbala (metrological station)	6.30	6.15	NA	6.12
10	Al-Samawa (metrological station)	7.22	7.03	6.71	7.15
11	Al-Diwaniya (metrological station)	6.47	6.06	6.34	6.90
12	Diyala (metrological station)	7.14	7.26	7.06	6.81
13	Al-Ramadi (metrological station)	7.23	6.99	6.62	6.75
14	Haditha (police station)	7.59	7.59	7.54	NA
15	Al-Ka'aim (police station)	7.97	NA	NA	NA
16	Faluja (police station)	6.96	7.31	6.62	NA
17	Samara (police station)	7.48	NA	7.17	6.95
18	Takrit (metrological station)	7.19	7.40	7.03	6.88
19	Beji (metrological station)	7.41	NA	NA	NA
20	Al-Mosil (metrological station)	7.10	7.12	7.26	6.96
21	Zakho (police station)	NA	7.5	7.54	NA
22	Karkook (metrological station)	7.88	7.96	7.91	7.15
23	Khanqeen (police station)	7.45	NA	NA	NA

*NA: not available

Table (3): Absorbed dose rates, effective doses, morbidity and mortality risks from lifetime (70 year) external exposure to ambient γ-radiation level:

Parameters	Mean	Range
Absorbed dose rate in air (µRad/hr)	7	5.91 – 7.97
Absorbed dose rate in air (µGy/hr)	0.07	0.0591 – 0.0797
Effective dose equivalent (mSv/y)	0.42	0.36 – 0.48
Lifetime morbidity health risk (whole body)	0. 24%	0. 2% – 0. 27%)
Lifetime mortality health risk (whole body)	0.18%	0.15% – 0. 2%

Table (4): Lifetime (70 years) cancer mortality and morbidity risks to various body organs and tissues as a result of external exposure to indoor and outdoor gamma radiation:

Body organ or tissue	Possible radiation risk (extra cancer cases per million exposed individuals)	
	Mortality risk	Morbidity risk
Bladder	88.2	176.4
Bone surface	14.7	29.4
Breast	58.8	117.6
Colon	249.9	441
Leukemia (Bone marrow)	147	147
Liver	44.1	58.8
Lung and Bronchus	249.9	264.6
Oesophagus	88.2	88.2
Ovary	29.4	29.4
Skin	5.88	2940
Stomach	323.4	352.8
Thyroid	23.52	235.2
Remainder	147	-

5. Conclusions:

(1) The effective dose equivalent is found to be less than the recommended dose limit for the public (1 mSv/yr). However, the results indicate that population exposure to natural background radiation causing considerable carcinogenic risks and genetic damage to a large number of people.

(2) The chronic excess cancer risk estimates attributed to external exposure to natural background γ-radiation level is found to be exceed the EPA’s $1*10^{-5}$ risk level of concern for all receptors evaluated

(3) The risk of developing radiation-induced fatal stomach cancer is found to be occurs at a largest extent in comparison with other exposed body organs and tissues.

(4) The appearance of cases such as cancer, inability to produce offspring, premature death, susceptibility to disease, and abnormal offspring among residents of the regions of interest is an evidence of the harmful consequences and biologically damaging effects associated with chronic doses of natural background ionizing radiation and public exposure to other carcinogens.

(5) No significant differences in the detected dose rates were observed during the monitoring period.

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مراقبة مستويات النشاط الاشعاعي البيئي لبعض مناطق العراق

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الخلاصة:

تم في هذه الدراسة رصد مستويات الجرع الاشعاعية المستلمة من قبل الساكنين في 23 منطقة سكنية ضمن العراق للفترة من 1992-1994 وخلال عامي 2011-2012 باستخدام عداد الوميض الحراري، ولم يلاحظ وجود فروقات معنوية في مستويات الجرع الاشعاعية المقاسة، وجرى تقدير خطورة الإصابة بالسرطان المميت لسكان المناطق بسبب التعرض الخارجي لاشعاعات كاما باستخدام نظرية (LNT). بينت النتائج أن معدلات الجرع الإشعاعية المكافئة للأشخاص الساكنين في المناطق المشمولة بالمراقبة بحدود 0.48 مللي سيفرت بالسنة وهي ضمن الحدود المقبولة من قبل الوكالة الدولية للطاقة الذرية وهي 1 مللي سيفرت بالسنة، وبالرغم من ذلك فقد اشارت النتائج الى انه هنالك احتمالية لحصول امراض سرطانية بمعدل 0.24% من الاشخاص المتعرضين للنشاط الاشعاعي الطبيعي، في حين كانت احتمالية الاصابة بالسرطان المميت 0.18%، واشارت النتائج أن احتمالية حصول سرطان المعدة المميت يتحقق بمعدل اكبر مما هو عليه الحال بالنسبة لبقية أعضاء وأنسجة الجسم. وأظهرت النتائج احتمالية حصول عيوب وراثية بمعدل 0.03% من الأجيال القادمة لسكان المناطق المشمولة بالمراقبة الاشعاعية كنتيجة للأضرار الجينية التي قد تلحق بالجينات الوراثية بسبب تعرض الغدد التناسلية للنشاط الإشعاعي الطبيعي.

الكلمات المفتاحية: النشاط الاشعاعي البيئي