Revisiting the fundamentals of Background Radiation – Chandigarh U.T. as case study

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Abstract. In this paper, we aim to bring forth some basic features of background radiation as well as the rationale for carrying out a systematic and precautionary investigation for the measurement of the background radiation dosage. The area considered for the present study is U.T. Chandigarh. The term Background radiation (BR) refers to all sorts of radiations around us including the strong and highly ionizing radio-active radiation emitted from the background/environment. Background radiation could be emitted from the soil, air, water, or any other means like construction, material, paint, food, and objects of daily use, or outer space (cosmic radiation). The motivation of the present work comes from the acknowledgement of the fact that prolonged and high exposure (more than the certain prescribed permissible limits) to BR can cause severe damage to human cells causing severe health issues and can even lead to fatality. Therefore, it is necessary to carry out an investigation in this domain to make precautionary efforts to safeguard the humans from the dangerous effects of this Background (radioactive) radiation. For this, a precautionary measurement of Background radiation (BR) is needed, and regular monitoring is required in areas where the probability of its persistence is high due to any known or unknown factors. Here, in this manuscript, we have presented a study of radiation dosage in case of one of the most renowned cities (U.T. Chandigarh) of the country. The investigation includes mostly all the major and critical areas of the city (including residential areas, markets, notable medical facilities like hospitals research centre's as well as educational institutions and many other places.

1 Introduction

In simple terms, the Background radiation (BR) represents the sum total of all the radiations emitted from all the surroundings (either natural like, air, water, earth, cosmic radiation from outer space or manmade like paints, X-ray machine etc.) engulfing us and is eligible

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of producing an impact (ionizing effect). The radiation exposure or radiation intensity could be measured through many systems or devices with different principle mechanisms, like Gas based detection systems (G. M Counters) [1,2], Scintillations detectors, Solid state detectors. Through gas-based detection system the radiation is measures through the ionization (primary and/or secondary) it produces in air or gas [2]. In the present study, we have used the Gas based detection systems (devices) to detect the background radiation which is quite successful to gauge the radiation by its ionization impact. One should note that the major reasons for the natural background radiation around us could be the inherent presence of radioactive traces in the environment. However, the contribution from the outer space (like cosmic radiation or emissions from supernova) toward BR is usually not very significant, which is around 10 to12 percent of total background radiation with an average of 0.33 milli Sievert/year (Average mSv/Year) [3]. The magnetic field of earth cancels the most of the outer cosmic radiation (from galaxies, supernovas, black holes, or solar flares). This happens because high energy cosmic or astro-particles with high energy and penetration power are mostly charged particles or protons with gets defected due to magnetic field of earth.

The continuous emission of highly energetic radiation with huge penetration strength due to spontaneous and exponential decay of unstable radioactive nuclei is called radioactivity. It is possible to analyse the disintegration of radionuclide which emits highly energetic radiation and can be studied through various methods [4]. This highly energetic and ionizing radiation is in actual of three types, alpha (α) particles (^4_2He), beta (β) particles (electrons) and gamma photons (γ). In nuclear and radiation physics, it is a well-established concept that the stability of the nucleus depends on its configuration, i.e., number of neutrons and protons contained in the nucleus**.** The instability or the stability (measured in terms of Binding energy/nucleon) of the nucleus is indeed a function of relative and net presence of neutrons, protons (Coulomb force), and neutrons to protons ratio (symmetry energy), leading to the emission of highly energetic radioactive radiation (radioactivity) or nuclear disintegration/integration (fusion and fission reaction). The natural tendency of nucleus to achieve stability leads to a continuous emission of radioactive radiation for years, decades or even centuries. Background radiation around us, including radioactive radiation, includes all the radiation sources like X-rays facilities, medical radiation treatment devices, mobile phones emitting radio-waves, and microwaves etc [5]. In our background, any spike in high radiation dosage could be mostly due to the presence of traces of radioactive traces in our background. The radiation emitted from the radioactive substance or its trace's (present in the soil, air, water, construction material, or any food item) is measured in terms of disintegrations per second. Three main units for radioactivity are:

1. Curie: One Curie (Ci) as a unit of radioactivity is equal to $3.7 \times 10^{10} dis/sec.$
2. Becquerel: Becquerel (one disintegration/second) is also a commonly used standard unit to acknowledge the radio-activity. One Bacquerel (1Bq) is equivalent to $2.703 \times 10^{-10}\ Curie\ (Ci).$

Rutherford (rd): One Rutherford (rd) =10^6, disintegrations per second, as a unit of radioactivity was introduced in 1946. However, Becquerel, the SI unit for activity, is much more referred to in present times. Naturally persistent radioactive background radiation, is recognized as the inherent radio-active radiation (highly energetic) present all around us in the environment surroundings

The radiation levels fluctuate from place to place and time to time, depending on the inherent presence of the traces of the materials which emit natural radioactive radiation. The background radiation also comprises of the contributions from the radiations from

external Universe including outer galaxies and terrestrial objects. The exposure can also be through inhalation or intake of materials, even the food which may contain very a smaller number of traces capable of emitting natural radioactive radiation. The radiation can be measured via. average dosage for a specified period of time, generally referred to as radiation dosage. The background or radioactive radiation can be detected with different detection devices which are based on different principles [2]. Detectors are based on the principal scintillation effect, ionization of gas and solid-state detectors. Digital Radiation dosage materials are also available which can easily give the values of the average dosage in a particular area. The radiation level can be measured from the impact it causes in the environment. The background radiation measurement means the radiation from all sources like radiation originated from outer space (outer galaxies), unstable nuclei or sources present inherently in air, water, soil or food. The radiation can also be emitted from made sources like e-waste, radioactive waste, biomedical waste, paints, chemicals or medical devices [5].

2 Consequences of exposure to prolonged or high Radiation Dosage

Atomic Energy Regulatory Board (AERB) [6], has specified the limitation for the radiation dosage with 20 mSv/year, when averaged over 5 consecutive years, when in a holistic consideration for the whole body. A finding detailed in Ref. [7] has mentioned about high radiation dosage area in the Ramsar city of Iran which on the Caspian Sea in northern Iran. Highest natural background radiation levels in the world are persistent in this area of Iran. Certain geological and hydro geological reasons have been mentioned for the presence of this high background radiation [7].

However, the specific reason of the persistence of high background radioactive radiation is the presence of ^{226}Ra in the local rocks. The background radiation can cause huge damage to humans and other living creatures. There are huge biological repercussions of background radioactive radiation exposure [8]. The highly energetic background radiation has a huge ionizing effect. This ionizing effect is also the principle on which the measurement of the intensity of dosage of radiation is based.

Living organisms are exposed to radiation from the huge unending distant outer cosmos due to cosmos showers from outer space (supernova, star formation/collapse) or other nearby surroundings like soil or water which can be both the natural and non-natural sources. Radiation can impact cells and thereby damage their genetic material (DNA). The cells in our bodies can repair this damage up-to a certain extent. This huge damage can also become cancerous [9]. Atomic blast can result into skin burns and acute radiation syndrome. More than a permissible limit exposure to BR can cause serious ramifications like cancer and cardiovascular diseases [10]. Some sources of radioactivity in daily life are X-ray machines (with approx exposure of 0.002 mrem); porcelain crowns or false teeth (0.003 mrem); Gas latern mantle when camping (0.003 mrem); Cigarettes (0.49 mrem per pack); Stone, brick or concrete building (7 mrem); Luminous wrist watch (0.06 mrem); Smoke detectors (0.008 rem); Coal fired power plant (0.03rem) [10].

Environment (earth's crust and atmosphere), consist of more than 80 nuclides, and some of them are also man-made radio nuclides. The major contributors of radioactivity-based background radiation are long decay chains of uranium-238 ($^{238}_{92}U$) and Thorium-238 ($^{228}_{90}Th$) and singly occurring potassium-40 ($^{40}_{19}K$) [11,12]. Fertilizers and other chemical sprayed on crops enhances the uranium nuclide content in soil and eventually makes food crops unsafe [12]. Brief review on radiation detection through G.M. Counter has

acknowledged the gas-based radiation detection mechanism [13]. G.M. Radiation detection mechanism is also explained in detail in [1-2].

3 Work Plan and Methodology:

Roentgen (R) is a fundamental unit which quantify the radiation, via. its effect of deposition of charge in air. The charge produced is the impact induced in the form of ionization produced by the highly energetic background radioactive radiation. One Roentgen (1R) refers to the value of $2.56 \times 10^{-4} C/Kg$ ion pairs in the air. One more effective unit rem, (Roentgen equivalent for man, rem), recognizes the radiation dosage in accordance with the amount of radiation absorbed in biological tissues. Its SI units are Sieverts (Sv). The one unit of Roentgen equivalent of man, i.e., 1 rem is equivalent to the 10 mSv (milli-sieverts). These two are also specified as the units of equivalent dose as the dose is calculated from the weighting factor (W_R). The equivalent dose Sievert is expressed as, Sv = absorbed dose in grays × W_R. Here, W_R expresses the potential damage caused to the cells which further depends on the type radiation and other related factors. Here, 1 roentgen = 2.58 x 10^{-4} C/Kg, as a unit for exposure to radiation.

The absorbed dosage (D) is also measured in terms of Gray (Gy).

Here 1 Gray (Gy) = 1 J Kg^{-1}, in S.I. units, and also 1 Gray = 100 rad.

Also, 1 rad = 100 erg/gram (in C.G.S. terms)

Equivalent dosage is commonly measured in terms of Sievert = J Kg^{-1} x W_R in S.I. terms.

Here radiation equivalent for man (rem) = 100 erg/gram x W_R (C.G.S.)

Here, 1 rem = 0.01 Sievert = 10 milli Sievert.

Also, effective dosage: Sievert = = J Kg^{-1} x W_Rx W_T

And similarly, the Dosage in rem = 100 erg/gram x W_Rx W_T

Where, $W_R$and W_T represent the radiation weighting factor and tissue weighting factor respectively.

For an occupationally exposed person, an approximate of 20 milli Sievert per year or 2 rem per year, has been penned as the maximum permissible values of dosage. Investigations on impact of background radiation on human health are available in literature [11,15]. The traces of radioactive materials in soil, sand, and rocks depend on the local geology of each region in the world [16]. Presence of materials like uranium and thorium manifests into the dose rate of background radiation [17]. In our present investigation we have used two devices showcased in Fig.1, which can measure the radiation dosage in terms of Avg. Micro Sievert/Hour levels.

Fig. 1. Reading for Radiation Dosage at Dhanas Lake side (upper left), Sector 32 Market (lower left), Sector 18 (Electronics market) (upper right), Daria Side Area (lower right)

Using two devices based on the principle of ionization of gas (gas-based detection system) [18,19] we have taken the readings of radiation dosage in many parts of the Chandigarh. A brief review of the Gas based detection system G.M. Counter is presented in [11]. For details see [1,2,20]. Chandigarh as a city is regarded as the "city beautiful" of the country with many educational, institutes, research centres, medical facilities (hospitals), markets and other institutions of national importance. We have carried out a systematic study with devices based on the principle of ionization of air molecules due to the radiation and measured it in terms of radiation dosage (Average micro-Sievert/hour). The area wise radiation dosage is presented and the approximate net average radiation dosage with respect to background radiation (which also includes highly energetic radioactive radiation) in Chandigarh is provided. Such analysis needs to be carried out in all the critical areas and zones of the country to access the intensity of background radiation dosage. Persistence of high BR can be due to the presence of any radioactive traces in environment or objects (even the paints, food material or concrete etc.) surrounding us. In general, there exists very less sensitivity in masses regarding the radiation exposure/dosage present and affecting us in the background. It needs to be investigated that whether the radiation dosage from our surroundings in form of background radiation is below the prescribed limit or not. This is needed to ensure the safety of surroundings from radioactive or background radiation perspective. In case the background radiation is above a certain high level, the possible or probable reasons behind it ought to be probed. Proper precautionary steps must be taken as prolonged exposure can have a huge non-repairable impact on the humans and environment. Our previous investigation [20] has mentioned and highlighted that why an assessment in of radiation sensitive area is essential even if it is a residential, commercial, industrial or other place (research center, medical or hospital space, academic institution).

4 Results and Discussion

We have carried out an investigation regarding the quantitative measurement of the radiation (background radiation) in the various parts/areas (institutions and specific places) of the Chandigarh. The measurements have been taken by the two instruments purchased with the grant sanctioned from the Department of Science and Technology and Renewable Energy, Chandigarh Administration, Chandigarh. The readings/quantitative measurement of the intense and highly radioactive radiation have been taken in the form of the dosage measurement (average micro-Sievert/hour). The average micro-Sievert/hour reading with both the instruments have been taken almost at all the critical parts and areas of the city including some educational institutions, hospitals, industrial area, and Daddumajra ground. The background or natural radioactive radiation is required to be detected randomly. If it is really a matter of concern or in the high-level range that it may affect the ecology and humans in those areas. The spot or actual place of radiation surroundings, where we have taken the measurements nearby any institution or around that particular area have been chosen randomly. In some cases, the radiation dosage measurements from the background radiation (average Sievert/Hour values) by both the instruments have been taken 2 times or more to verify and ensure the accuracy and to avoid any type of other impact which may affect the radiation measurement (radioactive dosage).

We have measured the background radiation (Average micro-Sievert/Hour) dosage in specific areas and provided the approximate average value for the overall case. This may give a fair estimation of the presence of background radioactive radiation, present in the UT, Chandigarh. Instead of sticking to 3 sets in a particular area or zone we have taken a number of readings depending upon the area and surroundings. In case more than 3 readings are needed for best estimation, multiple readings have also been taken. The varied number of reading's have been taken to serve the purpose of the work. In Figure, the devices are shown along with the readings at four specific areas. Radiation detection exclusively through G.M. Counter (i.e., a Gas filled based detection system) and its basic aspects are available in [21-24]. For much details one can refer to [20-26].

The overall value of dosage in U.T Chandigarh, comes out to be approximately 0.12 (in terms of Average μSv/H). We found that in all areas across the Chandigarh the readings of the radiation dosage in terms of average Micro Sievert/Hour lies between .10 Average μSv/H to .20 Average μSv/H.

Tracking the radioactive radiation exposure in all residential and market places, and even in critical area like dumping of Dadumajra (which may contain high amount of e-waste or any radioactive remnants) lead us to conclusion no area seems to be exposed to any high or extreme levels of radiation exposure. Tracking the nuclear radioactive levels around has major centers of city which includes educational institutes, medical facilities and research centre's of the city has yielded the result which indicates relatively no zone have harming levels of dosage. No area in U.T., Chandigarh yielded more than .20 or more than .20 average micro-Sievert/Hour of dosage.

Table 1. All Readings/Measurements in of radiation dosage across the Chandigarh**.**

Areas	**Specific Area**	**Readings (Average µSv/H)**	**Average Reading in that particular type of area (Average µSv/H dosage)**
Residential and Market places	Sector 45 A	0.12	0.12
	Sector 44 C, market	0.115	
	Sector 32 Market	0.115	
	Sector 10	0.13	
	Sector 38	0.12	
	Sector 16, Near Shanti Kunj	0.125	
	Sector 18, Electronics Market	0.125	
	Sector 17, Market	0.125	
	Leisure Valley	0.12	
	Near Transport Chowk	0.125	
	Sector 26, Grain Market	0.12	
Industrial Area	Phase 1	0.12	0.116
	Phase 2	0.11	
	Around Elante Mall	0.12	
Colleges/University	Panjab University Campus	0.12	0.117
	Nearby SGGS Khalsa College, Sector 26	0.11	
	O/s Dev Samaj College, Sector 45	0.115	
	SD College, Sector 32	0.12	
	At DAV College, Chandigarh	0.11	
	Near Department of Nuclear Medicine, PU, Chandigarh	0.12	
	Sector 25, PU Campus	0.13	
	Nearby Department of Physics, PU	0.115	
Sukhna Lake	Around Sukhna Lake Pathway	0.13	0.13
Dhanas Lake	Around Lake near waters	0.12	0.12
Dariya Lake Area	Near Dariya Lake	0.125	0.125
Daddumajra Dumping Ground	Around Daddumajra Dumping Site	0.13	0.13
Railway Station	Outside Railway Station	0.145	0.145
Nearby Research Centres	At Sector 20 (Nearby CSIO and CSIR)	0.115	0.115
Outside Hospitals	PGI, Sector 12	0.115	0.115
	GMSH, Sector 16	0.11	0.11
	GMCH, Sector 32	0.12	0.12
Approximately overall, Average Radiation Dosage in Chandigarh			0.12

5 Conclusion

The background radiation (BR) can be ionizing (highly intense) or non-ionizing (low intensity), which may or may not include the component of highly energetic and ionizing radioactive radiation respectively could be emitted from soil, air, water or any other material surrounding us. The radiation exposure affecting us can be from natural (soil, water, air, outer space like cosmic radiation) or man-made sources (X-rays, microwaves etc.). High or prolonged exposure to BR, due to any geographical/geological reasons or man-made sources and can lead to severe ill-effects over the longer period of time. The radiation effect certainly goes unnoticed as it cannot be directly witnessed or encountered. But its detrimental effects become visible only when the hazardous effects manifests into critical health ailments after a prolonged or high exposure. Any suspected region or area need to be investigated for the radiation dosage levels. If any high levels of radiation are detected in a specific zone at early stages, then proper steps can be undertaken well within time to control or curb its effects. In Chandigarh, the overall BR is approximately 0.12 Average micro-Sievert/Hour. The overall average radiation level seems not significant enough to call for any immediate concern. It is worth mentioning that highly energetic background radiation presence is hardly altered or impacted by any seasonal changes or related surroundings. However, one could note that excluding the manmade sources of Background radiation, the radioactive material presence could probably be the main factor behind any high or prolonged BR persistence.

6 Outlook

There seem no specific area or zone in the city where radiation is of such levels that it may be labelled as alarming. However, our study cannot be admitted as wholly inclusive because our findings only represent the background radiation aspect or its effects from radioactive traces or by any other means. Any possibility of direct inhalation, consumption or presence of radioactive traces can potentially cause other harmful effects on human beings. Other investigations (except background radiation) can also be undertaken to check and track the presence of radioactive traces or elements in soil, earth, or water which can spoil the food chain leading to extremely detrimental consequences.

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