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Short Review Paper

A review on occurance of radioactive elements in different states of India

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Abstract

This study aims to identify the occurrence of radioactive elements and the radiation emitted by them with their hazards in all over Indian states to control concentration of these elements and radiation level within safe limit and to protect the population, living around contaminated area. An extensive literature survey on radioactive contamination and natural radioactivity enhanced by different sources viz. the use of phosphate fertilizer, building materials (cement), phosphate rock, has been carried out. It has been found on reviewing the survey done; that radioactive contamination in India's environment is not exceeding the limit prescribed by UNSCEAR, WHO, and AERB.

Keywords: Drinking water, Heavy metals, Permissible limit, Pollution index.

Introduction

IAEA in 1996 estimated that 80% of the radiation dose is contributed by natural radioactivity and only 20% by cosmic rays and nuclear processes. Radionuclide's: uranium, thorium, potassium, radium, etc generally released in very small amount to the environment and transported through water or air[1]. Uranium, Thorium, and radium are naturally occurring radioactive metals found in trace level in soil, rock, water, plants, and animals. These three radioelement's are responsible for generation of gamma ray and hence there is a direct relationship between concentration of primary radioelement's and gamma ray exposure rate[2], Uranium (U), has three naturally occurring isotope: U-238 (half life 4.47 billion years), U-235(half life 700 million years), and U-234(244,000 years), and is weakly radioactive and contributes to low level of natural background radiation in the environment and used in nuclear power generation. Uranium is present in soil, rock and water. Most of the uranium found in environment in the form of U-238 but U- 234 is highly reactive among three. Uranium eventually decays to radium which decays to radon. Thoriumn (Th) exists as Th-232(half life 14 billon years), Th-230 (half life77000 years), Th-228 (half life 1.9 years) naturally however man made thorium isotopes are rare, and almost never enter the environment. Radium (Ra): three isotopes Ra-226(half life 1600 years), Ra-228 (half life 5075 years), and Ra-224 (half life 3.36 years) are known. Radium concentration in ground water will be high in the area where rock and soil are having high concentration of radium and its concentration also increase by uranium and thorium mining, as Ra-226 is a part of uranium decay series and Ra-228 and Ra-224 are the part of thorium mining. All the isotopes of radium are radioactive and decay to produce radon gas. Radon (Rn) (half life 3.3 days) is an odorless, colorless, radioactive gas, comes from natural decay of uranium and radium, found in nearly all rocks and soils. Radon can move up to in to building through opening in floor or walls which are in contact with ground and can accumulate in building and, over time can cause series health hazards like lung cancer[3]. In point of view of protection against indoor radon it is important to understand the generation and migration of radon from its sources and all factors influence this process[4-6]. All the radioactive materials discharges on the environment as per following pathway: i. Cloud emersion (external exposure and inhalation) ii. external exposure from deposits onto ground, freshwater, and marine sediments iii. ingestion of aquatic foodstuffs iv. ingestion of drinking water v. Ingestion of terrestrial foodstuffs[7]. Natural radioactivity is widely spread in the earth environment and depends mainly on geological and geographical conditions[1]. There are 20 nuclear power plants 4 uranium mines, 2 thorium mines, 2 fuel fabrication plants, 5 heavy water plants, operating in India, although as per survey of 2011, it has been found that the dose of occupational workers were within prescribed annual dose limit of 30mSv but four workers had been found to exposed to higher radiation dose rate accidently[8].

Radioative elements has been reported in India

Uranium is the major radioactive element reported most abundantly in various part of India in addition Thorium, Potassium-40, Carbon-14, Radium have been also reported.

Radioactive contamination occurred in various states of India

Reported parameters regards radioactive contamination in different locations of India has been presented in Table-1.

Table-1: Radioactive contamination in different locations of India.

S.no.	Parameters	Results	Sample	Location	Ref.
1	U concentration:	<2ppb to 212ppb	Water	Bathinda, Punjab	9
		0.5-579 μgl^{-1}	-	SW, Punjab	10
		1.47 to 10.66 ppm	Soil	Karbi Anglong District of Assam	11
		2.03 to 3.52 ppm	Soil	Ganderbal, Jammu & Kashmir	12
		0.1±0.01 ppb to 19.6±1.ppb	Water	Maharashtra, U.P., Orissa, Andhra Pradesh, Madhya Pradesh, Kerala	13
		0.75 $mgkg^{-1}$ to 26.71 $mgkg^{-1}$ 0.37 $mgkg^{-1}$ to 4.42 $mgkg^{-1}$	Soil Rock	Kangra, Himachal Pradesh	14
2	Activity concentration of radionuclide's	9 to 28 Bq kg^{-1} (^{226}Ra),21-43 Bq kg^{-1} (^{232}Th), 19-35(^{40}K)	Cement	Aligarh region, UP,	15
		(0.08±0.06 to 3.24±0.31) dpm/kg,^{226}Ra; (227±5 to910±20)dpm/kg: (2.3±0.1 to 16.2±.02)dpm/kg ^{238}U; (0.00±0.09 to 0.86±0.14) dpm/kg ^{234}Th;	Ground water	Gujrat	16
		10.54 to 49.67 Bq/kg (radium);	Soil	Karbi Anglong District of Assam	11
		6.43 to 18.89 Bq kg^{-1}(radon)	Soil	Ganderbal, Jammu &Kashmir	12
		0.50 to 22 Bq l^{-1} with the mean value of 4.42 Bq l^{-1} (radon)	Water	Bikaner and Jhunjhunu, Rajasthan,	17
		941 to 10,050 Bq m^{-3} with the mean value of 4561 Bq m^{-3} (radon) 21-674 Bq/kg^{238}U,11-44 Bq/kg, ^{232}Th, 22-683Bq/kg^{226}Ra and51-295Bq/kg ^{40}K ,	Soil Soil	Bikaner and Jhunjhunu, Rajasthan,	17 18
		11.54 to 26.71 $Bqkg^{-1}$ (radium) 2.58 to 26.06 $Bqkg^{-1}$ (radium)	Soil Rock	Kangra, Himachal Pradesh	14
3	Radon equivalent (Ra_{eq})	60.8 to 121 Bq kg^{-1}	Cement	Aligarh region, UP	15
4	External hazard index	0.16 to .30	Cement	Aligarh region, UP	15
5	Radon exhalation rate	47.7 to 205.6 $mBqkg^{-1}h^{-1}$	Tobacco plant	-	19
		502.34 to 2062.53 $mBqm^{-2}h^{-1}$.	Soil	Karbi Anglong District of Assam	11
		5.05 to 21.89 m Bq kg^{-1} h^{-1}	Soil	Ganderbal, Jammu & Kashmir	12
		11.2 to 54.09 Bq/kg with mean 35.73Bq/kg (^{226}Ra), 23.47 to 49.62 Bq/kg with mean 37.75 Bq/kg (^{232}Th) 13.43 to 223.92 Bq/kg with mean 159.83 Bq/kg (^{40}K)	Cement	Tamilnadu	20
		502 $mBqm^{-2}h^{-1}$ to 1163 $mBqm^{-2}h^{-1}$ 106$mBqm^{-2}h^{-1}$ to 1149 $mBqm^{-2}h^{-1}$	Soil Rock	Kangra, Himachal Pradesh	14
6	Annual effective dose	1.37 to 60.06 $mSvy^{-1}$ with the mean value of 12.08 $mSvy^{-1}$, (due to radon)	Water	Bikaner and Jhunjhunu, Rajasthan	17

Radioactivity in soil and sediments

Radionuclides released in the atmosphere undergo decay and get deposited initially on the upper surface of soil by wet or dry deposition in short periods but they quickly dispersed in to first centimeter of soil[7]. Agricultural soils can cause direct harm to human and environment so it needs special concern. Radionuclide's uranium, thorium, potassium, are generally enter in soil by the use of phosphate fertilizer, phosphate ore mining, etc and the spatial distribution of these radionuclide's is variable and depends upon parent material characteristic as well as on weathering processes[21] . river sediments are also a major source of radioactivity that attributes significantly to the background level of radiation so its use as building material can cause great radiological treat to the person living in that area[22].

Radioactivity in phosphate ore, rock, and fertilizer

It has been found that phosphate rock contains different amount of naturally occurring radioactive materials e.g. U, Th, and their decay products and K. gamma rays and alpha particle emitted from nuclides of uranium and thorium series present in phosphate rock are the major source of external and internal exposure [23-25]. It has been observed that more than 30million ton fertilizers are consumed worldwide to increase crop production and land renewal[26]. These fertilizers contaminated the cultivated land by NORM[27]. Uranium and its decay products tends to upgrade in phosphate deposits of sedimentary origin, where typical uranium series concentration is about 1500 $Bqkg^{-1}$ [28]. Therefore after processing of rock into fertilizers most of the radionuclide's comes into fertilizers than to soil and plant and finally via food chain to human through internal exposure and become a major source of radioactivity[29] and the most important pathway of exposure to radioelement present in soil is ingestion[30] in addition during transportation and handling processes they enters in the workers body through external exposure[31].

Radioactivity in building materials

Building materials are also a source of radon in houses and the general recommended permissible limit of exposure of indoor radon is10Bqm^{-3} [32]. Naturally occurring raw building material and processed products have presence of radionuclide's of uranium, thorium and pottasiim-40 series. High concentration of radionuclides in building materials results in high indoor doses and the radon level inside houses depends on ventilation of room and it has been proofed that the poor ventilation increases the level and exhalation rate of radon[33]. In tamilnadu it has been found that the cement used for construction purpose are safe in point of view of radioactivity[15].

Radoactivity in water

Radioactive elements may be present in ground water of all the area, nearest to the sources like phosphate ore deposits, agricultural area where phosphate fertilizers are in use, coal mines, nuclear plants, and other natural and anthropogenic sources. Underground water move through rock and soil containing radon and radon gas get dissolved in water and make it contaminated[34] but there is less possibility of presence of radon in surface water because it get released into air after some time[3] and radon concentration decreases with depth of the area where water circulates[35]. Among all radioactive elements uranium is one which has been occurred more abundantly in Indian water samples analyzed. Concentration of uranium in water depends on the flow of water through complicated fracture network within the rock, pH, calcium content and other parameters of ground water[36]. In Punjab there are two coal fired power station and it was considered as source of radioactive contamination in water sources but it has been cleared from the study of fly ash of coal fired plant that fly ash coming from the coal thermal plant are not a possible source of radioactive contamination in water but the agrochemical processes occurring in calcareous soil and use of agricultural additives are the reason behind high concentration of uranium found in shallow water[9]. A high concentration of radon in ground water around granite rock exposure observed in Mandya district, Karnataka but total dose due to ingestion and inhalation were found within limit of 100 μSvy^{-1} prescribed by WHO[37].

Hezards occurred due to radioactive contaminant

Ionizing radiation has so much energy it can knock electrons out of atoms, a process known as ionization. Ionizing radiation can affect the atoms in living things, so it poses a health risk by damaging tissue and DNA in genes. One of the great source of ionizing radiation are radioactive elements[3]. Human population is continuously exposed to the radiation emitted from different natural sources; this exposure is continuous and unavoidable characteristic of life on earth. U, Th, and K are the important cause of terrestrial radioactivity[38]. These radionuclide's and their decay products emit alpha particle, beta particle, and gamma rays in which gamma ray is important source of external and alpha particle is an important source of internal exposure, as it enters in body by the inhalation of radon and its progenies consequently directly come comes in contact with bronchial tissues and cause radiogenic lung cancer[39-41]. It has been found that high dose causes deterministic whereas low dose causes stochastic effect and can be described in terms of randomnicity and probability respectively and low dose exposure below 100-200mSv does not cause heritable effect[42].

Conclusion

Average concentration of radionuclides and all calculated parameters were found within safe limit. Concentration of radionuclide's can higher at the source site viz. area of phosphate rock, phosphate fertilizer plant, agricultural area where phosphate fertilizers are in use for improving crop production and soil renewal but as the distance increases from the source the concentration of these nuclides decreases in water as well as in air and soil. It has been found that concentration of

radon (final decay product of all radioactive elements) can be higher in ground water but much lower in surface water so, it should be advisable to people living in contaminated area to use surface water: river, lake, canal water coming in houses by tap for drinking purpose.

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