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Impact on Air Quality of Radioactivity Concentration 0-3 K.M Radial Range from Panipat Thermal Power Plant

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Abstract

Natural radioactivity is ubiquitous on Earth, primarily originating from uranium, thorium, and potassium. Radon-222 (^{222}Rn), a naturally occurring radioactive gas and a decay product of Radium-226 (^{226}Ra), is part of the Uranium (^{238}U) decay chain. Coal-based thermal power stations release emissions in both gaseous and particulate forms, containing radioisotopes that contribute to radiation exposure in the surrounding environment. This study presents the findings of measurements conducted twenty air samples through a sensitive tool for detecting nuclear radiation Digital Geiger Muller Counter (GQ GMC-300E Plus) to estimate natural radioactivity discharged into the atmosphere within the radial range 0-3 k.m from the Panipat Thermal Power Station as origin, located in Panipat, Haryana, with an installed capacity of approximately 1367.8 MW(e). The results for ambient gamma dose rates at the sites of study radioactivity concentration in the ranged from 0.52 Bq/m^3 to 0.77 Bq/m^3, which is below to the global average for airborne radioactivity according to United States Environment Protection Agency recommendations. it states that overall air of studied radial region around Panipat Thermal Power Plant is found within the safe range of radiological risk and not harmfully affecting the environment.

Key words: Natural radioactivity, Radon gas, Fly ash, Coal based power plant, Air samples, Geiger muller counter, Radiation exposure

Natural radioactive materials whose radiological risks are amplified by human activities that concentrate or redistribute them. Examples include mining and processing of uranium or thorium, combustion of fossil fuels like coal (producing fly ash and bottom ash), use of phosphate fertilizers that raise soil radioactivity, and incorporating radionuclide-containing residues in building materials. These activities elevate radiation exposure beyond natural background levels, posing environmental and health concerns. This is termed as (TENR) technologically enhanced Naturally Occurring Radioactivity. All environmental substances inherently harbor natural radionuclide's with diverse isotopic compositions. The average individual is subjected to ionizing radiation at an estimated dose of 2.4 mSv per year from these natural origins, with radon exposure alone accounting for approximately 1.0 mSv annually [1].

Natural radionuclide's predominantly stem from the decay chains of ^{238}U, ^{232}Th, and ^{40}K. Coal, inherently containing trace quantities of uranium and thorium, becomes a source of radiological concern, with ^{222}Rn radon gas from the ^{238}U decay series being a significant contributor to radiation exposure. As coal combustion remains the dominant method of electricity production in thermal power plants, it not only releases radon gas a decay product of ^{238}U—but also generates substantial quantities of solid byproducts, including fly ash and bottom ash. The radionuclide activity concentrations in coal typically range between 30 to 100 Bq/kg for ^{40}K, 10 to 600 Bq/kg for ^{238}U, and 10 to 200 Bq/kg for ^{232}Th respectively [2].

Fly ash and bottom ash, byproducts of coal-fired power plants, are frequently utilized as filtering agents in construction materials, serving as substitutes for raw cement, sand, and in the fabrication of ceramics, glass-ceramics, and zeolites. These applications, however, introduce radiological considerations due to the inherent radionuclide content of the ashes, which may pose potential health risks to humans upon prolonged exposure [3,4]. The incorporation of coal ashes offers economic benefits but may influence the radiation exposure experienced by individuals within indoor environments. Specifically, this practice elevates both external and internal radiation levels, primarily through the inhalation or ingestion of radon gas and its progeny, thereby presenting potential health concerns [5].

Radon, an inert and naturally occurring radioactive gas resulting from the decay of radium, emits alpha particles capable of inflicting damage to pulmonary cells, potentially leading to lung cancer upon inhalation due to its radiological risks. Among its isotopes, Radon-222 is predominantly monitored owing to its relatively extended half-life of 3.824 days. Odorless and pervasive, it constitutes the principal source of radiation exposure for humans, contributing to over half of the average annual dose attributed to natural background radioactivity affecting the population [6]. In 1987, the International Agency for Research on Cancer (IARC),

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operating under the World Health Organization (WHO), formally classified radon as a confirmed human pulmonary carcinogen, acknowledging its significant role in the etiology of lung cancer [7].

Considering the concerned surrounding radon gas exposure and associated gamma radiation, it is imperative to assess radiological hazards and evaluate potential health risks. The objective of this study is to investigate gamma radiation levels in air samples collected within a radial range distance of 0–3 km from the Panipat Thermal Power Station, focusing on the spatial distribution and intensity of radiological exposure in the area.

MATERIALS AND METHODS

Geology of study area

The study area shown in (Fig 1), "Panipat Thermal Power Plant" is Located in Khukhrana, Panipat in Haryana. The Power Plant is one of the coal-based power plants of Haryana Power Generation Corporation Limited (HPGCL), It was formerly Known as the Tau Devi Lal Thermal Power Station. The site is close to the Asan & Khukrana Railway Station on the Panipat Safido Section of the North Western Railway. Its Primary fuel is Coal. It has Four Operational Units Operated by HPGCL. its first unit commission in 1979 with capacity of 448MW. Today with four operational units its total capacity of electricity supply is 1367.8 MW. This area is highly fertile enriched with alluvial soils, flat topography broken by numerous ponds, lakes, and sub-rivers. It is located between 29°23'51" N and 76°53'25" E. It's elevation from sea level is 236 m (774 ft).

The Panipat Thermal Power Plant Station (PTPS) is one of the coal-based power plant in Panipat Haryana, India. It has four operational units that generate 1367.8MW of power. Its supplier is HPGCL India [8].

Sample collection

For the purpose of air sample collection in this study, a systematically designed sampling network was established within a 3 km radial distance from the Panipat Thermal Power Plant, situated at 29°23'N latitude and 76°53'E longitude. This radius was selected to encompass the immediate environmental impact zone of the plant, where radionuclide dispersal from emissions and particulates is expected to be most significant. Samples were gathered from twenty distinct locations within this radial range, representing varied local environmental settings such as residential areas, open fields, and downwind regions, taking into account the influence of meteorological factors like wind speed and direction. Samples were collected exclusively when the plant operated at full capacity, ensuring all units were active. Data acquisition was performed at a height of 6 feet from sampling points devoid of obstructions such as tall trees or buildings within a 30-meter radius [9]. Counts per Minute (CPM) were recorded using a digital radiation detection device, eliminating the need for sample preparation and ensuring real-time accuracy in measurements.

Radioactivity instrumentation

The air samples were analyzed using a Digital Geiger-Mueller Counter radiation detector, specifically the GQ GMC-300E Plus model, which is known for its sensitivity and reliability in detecting low levels of ionizing radiation. This portable and user-friendly device facilitated the direct measurement of radiation activity in the air samples, making it ideal for on-site environmental monitoring. The GQ GMC-300E Plus operates by detecting beta and gamma radiation of the range 0.1 to 1MeV emitted by natural radionuclide's present in the air. Its digital interface LCD Display (with dot matrix) calibrated with the device and provides precise readings in real time, ensuring accuracy and minimizing the potential for human error during data collection. Additionally, its wide detection range and capability to store data for subsequent analysis enabled the systematic evaluation of radioactivity across various sampling locations. The choice of this instrument was guided by its proven performance in environmental studies and its ability to provide baseline radiation data effectively. Its portability allowed for ease of deployment across the different sites, ensuring consistent and high-quality data collection, thereby contributing to the robustness and reliability of the study's findings.

Data accuracy and collection

To achieve precise measurements of radioactivity concentration, it was essential to collect a substantial number of air samples while accounting for background radiation. The reliability of the results is directly linked to the volume of samples analyzed, highlighting the importance of thorough and consistent data collection [10]. The sampling process began by positioning the Geiger-Mueller counter either directly on or in close proximity to the target area to ensure accurate detection of radiation levels. Radiation counts were measured in counts per minute (CPM), with the initial reading documented as 29

CPM. Subsequently, 20 additional readings were taken at various locations within the 3 km radial range of the Panipat Thermal Power Plant. These readings ranged from a minimum of 29 CPM to a maximum of 43 CPM, capturing the spatial variability of radiation levels across the area.

RESULTS AND DISCUSSION

Measurement data

The radioactivity levels in the air were measured using the Geiger-Mueller instrument during the period from April to May 2023. These cumulative measurements provide a detailed snapshot of the gross gamma radiation levels present in the environment during this timeframe. By focusing on this specific period, the study ensures that the data reflects a comprehensive analysis of radioactivity concentrations under consistent operational and environmental conditions.

The results of the air radioactivity measurements are summarized in the table below, where the counts per minute (CPM) readings were converted to Becquerel's (Bq) for standardized representation of radioactivity levels. The conversion factors used are as follows:

64 CPM = 1.15 Bq

55.65 CPM = 1 Bq

These conversion ratios were instrumental in quantifying the measured radiation levels and translating them into internationally recognized units. This approach facilitates the accurate interpretation of data and provides a clear understanding of the radioactivity concentrations in the sampled air.

Table 1 Air samples collected from 0-3 K.M. radial range of Panipat thermal power plant, (Haryana)

S. No.	Label of sample	GPS location		Radiation level	
		Latitude	Longitude	CPM	Becquerel (Bq.)
1.	SAM – A	29.395640N	76.852189E	33	0.59
2.	SAM – B	29.386296N	76.858594E	37	0.66
3.	SAM – C	29.385878N	76.872256E	31	0.55
4.	SAM – D	29.392929N	76.872504E	29	0.52
5.	SAM – E	29.391680N	76.865749E	34	0.61
6.	SAM – F	29.396776N	76.860887E	39	0.70
7.	SAM – G	29.398181N	76.860953E	35	0.62
8.	SAM – H	29.403321N	76.861198E	32	0.57
9.	SAM – I	29.403178N	76.870571E	29	0.52
10.	SAM – J	29.405268N	76.876016E	39	0.70
11.	SAM – K	29.408607N	76.882151E	42	0.75
12.	SAM – L	29.406029N	76.887580E	30	0.53
13.	SAM – M	29.401983N	76.896122E	36	0.64
14.	SAM – N	29.399016N	76.898618E	32	0.57
15.	SAM – O	29.398240N	76.894147E	43	0.77
16.	SAM – P	29.394306N	76.893992E	34	0.61
17.	SAM – Q	29.394243N	76.886489E	40	0.71
18.	SAM – R	29.385832N	76.875235E	33	0.59
19.	SAM – S	29.385836N	76.873405E	36	0.64
20.	SAM – T	29.386433N	76.865984E	29	0.52

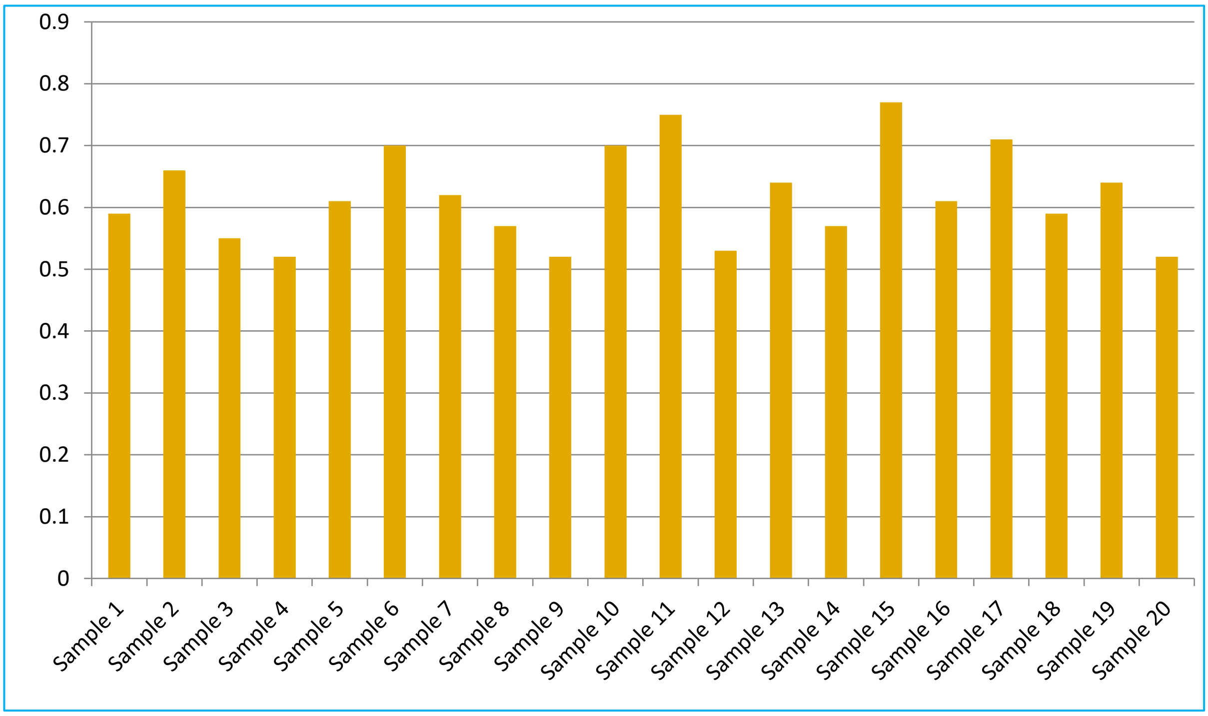

Fig 1 Radioactivity concentration in air (in Bq.)

The air we breathe is essential for life, and it is crucial that its activity levels align with the recommendations set by the International Atomic Energy Agency (IAEA). Reducing radiological pollution is vital for the well-being of humanity. The data collected in this study will serve to monitor and compare the levels of radionuclide's in the air surrounding the Panipat Thermal Power Plant. Two distinct risks associated with coal-fired power plants are assessed in this research: the radiological risk from ionizing radiation and the risk from the decay products of radon gas. Both of these risks have harmful effects on human health and should not be overlooked.

CONCLUSION

In this study, we evaluate the radiation risks posed by the concentrations of natural radioactivity in the air within a 0–3 km radius around the Panipat Thermal Power Plant. Based from models established by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), our analysis suggests that the radiation levels in this area are unlikely to present a significant threat to the health of people living nearby. The results indicate that the radiation exposure remains within acceptable limits, and the risks of harmful effects are minimal. Furthermore, the study takes into account various factors such as meteorological conditions and the plant's operational status, ensuring a comprehensive assessment of potential radiation exposure. Based on these findings, it can be concluded that the radiological impact of the Panipat Thermal Power Plant on surrounding populations does not exceed safety restrictions. Nonetheless, continuous monitoring is recommended to ensure long-term safety and to detect any potential changes in radiation levels.

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