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Natural Background Gamma Radiation Levels in the Environs of Proposed Petro-chemical Industry Near Jadcherla, Telangana State, India

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ABSTRACT

A survey of environmental gamma radiation levels is attempted in the geographical site under construction to establish a petrochemical industry. The knowledge of natural background radiation is one of the significant steps in establishing the chemical industry. Some chemical operations such as chemical refinement may sometimes influence the natural radiation levels. The attempt of measurement of natural background gamma levels in the present paper is to establish the baseline data, which on further measurements will be useful to analyse the changes in natural background radiation levels at the time of operation of a chemical plant. The present investigation shows the activity levels of gamma radiation in the site under construction at 65 locations. The gamma levels are found to vary from 1459 μGyy^{-1} to 2765 μGyy^{-1} with the average of 2141±304 μGyy^{-1}. It is to be noted from the study that the average gamma radiation levels at two sample locations, cement mixing point (2307 μGyy^{-1}) and stone crushing point (2529 μGyy-1) have been elevated. The elevated radiation levels at the two sample locations can be attributed to the radioactive dust emitted in the process of crushing stones and cement mixing.

INTRODUCTION

Natural background gamma radiation from natural sources and the exposure of human beings is a continuous and unavoidable feature. Earth cannot be without the presence of natural radionuclides, as they naturally exist in rocks and soil. The environmental gamma radiation dose from natural sources is the most significant and immediate concern to lead the situation of the radioactive pollutant environment (Spycher et al. 2015). The environmental gamma radiation levels vary in different regions and depend on factors like the radiation properties of soil and rock, natural properties of building construction materials, and the lifestyle of the dwellers (Nambi et al. 1986, UNSCEAR 1993, Dade 1996, Sreenivasa Reddy et al. 2005, Sreenath Reddy et al. 2010, Srinivas Reddy et al. 2015). Environmental gamma radiation is caused by radioactive elements with a long half-life, which exists in primary rocks of the earth's crust. This is caused by the decay of uranium and thorium as natural radioactive resources that pollute environmental resources of their surroundings (Kardan et al. 2013, Soltani et al. 2014).

There have been significant studies in the investigation of gamma radiation around the petrochemical industry for the analysis of the impact on the radioactive pollution due to the different operations of producing the petrochemical products (Mansour et al. 2012, Emelue et al. 2014). The process of production in petrochemical industry may cause the generation of naturally occurring radioactive materials. The contamination of radionuclide with petroleum and natural gases will be the source for gamma radiation (UNSCEAR 2000). In addition, gamma radiation is used as a nuclear diagnostic technique to investigate the distillation columns in petrochemical industry (Vernal et al. 2003). A very few studies were carried out on the dose received by the workers in petrochemical industries unlike ordinary dwellings and mining environs (Smith et al. 2003, Avwiri & Agbalagba 2012, Samad et al. 2017). In the present study, the environmental gamma radiation levels at various sample locations that are under construction for chemical industry have been worked out. The interest in the present investigation is to establish the baseline data of natural background gamma radiation levels at different zones of the proposed area under construction for petro-chemical industry. There may be fluctuations in natural gamma radiation levels due to the influence of chemical operations carried out in the industry in the future. The baseline data established in the present investigation will be useful for the analysis of radioactive pollution levels, if any, at the time of plant operation.

MATERIALS AND METHODS

Study Area: The present study was carried out in the

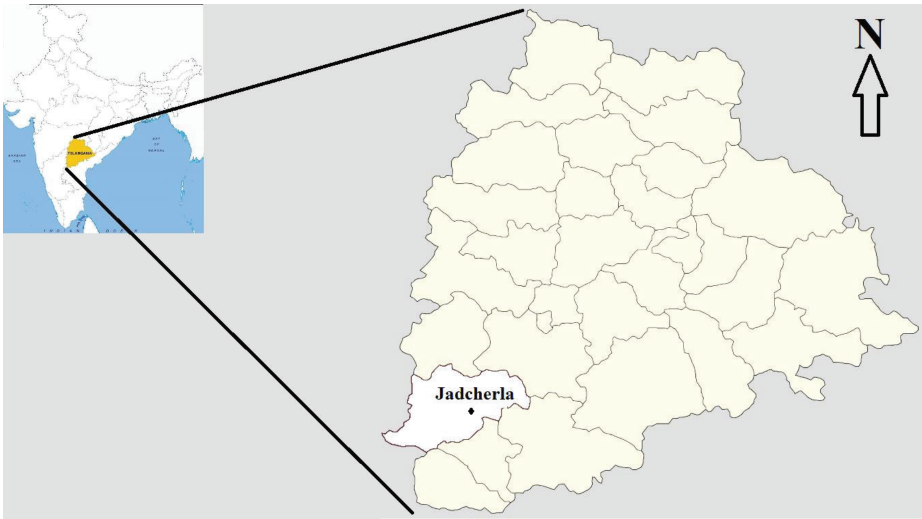

Fig. 1: Location map in Jadcherla of Mahabubnagar district, Telangana state, India.

Table 1: Estimated natural background gamma radiation levels at different locations.

Location	Natural background gamma radiation levels (μGyy^{-1})	Location	Natural background gamma radiation levels (μGyy^{-1})	Location	Natural background gamma radiation levels (μGyy^{-1})
S1	2419	S24	2227	S47	2035
S2	2342	S25	2227	S48	2035
S3	2496	S26	2112	S49	1728
S4	2304	S27	2150	S50	1766
S5	2381	S28	2150	S51	1651
S6	2342	S29	2189	S52	1690
S7	2304	S30	2381	S53	1728
S8	1882	S31	2573	S54	1958
S9	2266	S32	2688	S55	1459
S10	2342	S33	2688	S56	1574
S11	2304	S34	2304	S57	1574
S12	2074	S35	2227	S58	1958
S13	2074	S36	2419	S59	1958
S14	1997	S37	2611	S60	1997
S15	2035	S38	2458	S61	1805
S16	2150	S39	2496	S62	1843
S17	2150	S40	2419	S63	1882
S18	2074	S41	2650	S64	1920
S19	2150	S42	2726	S65	1920
S20	2189	S43	2765	Min	1459
S21	2112	S44	1766	Max	2765
S22	2150	S45	1766	Average	2141
S23	2112	S46	2035	S.D.	304

area located at 2 km distance from Jadcherla town in Mahabubnagar district of Telangana state, India and 90 km south-west from Hyderabad, the capital of the State. In 2011, Jadcherla was upgraded from village to town. It is a historical town known for its cultural heritage. Fig. 1 shows the study area of natural background radiation levels in a proposed petrochemical industry, which is in the initial stage of construction.

Measurement of radiations: Measurements of radiation were made at 65 number of sample locations selected randomly by covering most of the places in geographical site under construction for this study. A portable NaI crystal based μR-survey meter (Ms. Nucleonix Systems Limited, Hyderabad make) type UR705 and measures gamma dose-rate in the range of 1 μR/h to 9999 μR/h was employed in the present investigation. This portable survey meter, designed around integrally coupled 1″ × 1″ NaI (Tl) scintillator to a 1 1/2″ PMT, will offer an optimum performance in counting low-level gamma radiation dose rate. This unit can measure and display dose rates in the range of 0-10000 μR/hr on a dot matrix LCD Display. Dose rates close to natural background levels can be measured accurately. This unit is ideally suitable for radiometric and environmental radiation monitoring that involves low-level radiation dose rates.

The natural background gamma radiation levels were measured in two modes, (i) at the ground level and (ii) at a height of one metre from ground level at each sampling location. The data depicted in figures and tables is mean value of the both the readings. The data were acquired during day time in the outdoor environment. The diurnal variations in the gamma radiation levels were not considered. The exposure rates were converted into equivalent doses using the appropriate conversion factors (UNSCEAR 2000). The calibration of the survey meter is carried out at Ms. Nucleonix Systems Limited, Cherlapally, Hyderabad. It is also established earlier by our research group that the results of

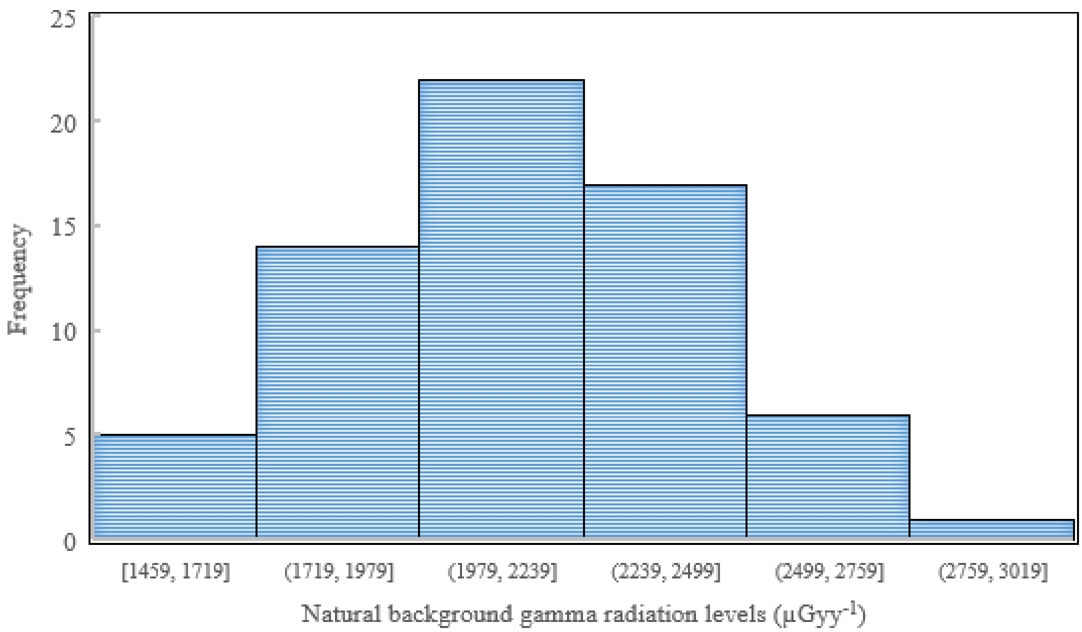

Fig. 2: Frequency distribution of natural background gamma radiation levels.

Table 2: The natural background gamma levels at different zones.

	Cement mixing point (μGyy^{-1})	Sand storage point (μGyy^{-1})	Granite storage point (μGyy^{-1})	Stone Crushing point (μGyy^{-1})	Other location points (μGyy^{-1})
Number of measurements	11	7	11	14	22
Min	1882	1997	2112	2227	1459
Max	2496	2150	2227	2765	2035
STD	155	56	42	167	165

natural background gamma radiation levels estimated by using μR-survey meter are in good agreement with data obtained by thermoluminescence dosimeters TLDs (Sreenivasa Reddy et al. 2002, 2005).

RESULTS AND DISCUSSION

The estimation of natural background gamma radiation levels was carried out at 65 locations of geographical site under construction for a petrochemical industry. The estimated average levels of environmental gamma radiation are given in Table 1. The natural background radiation levels were found to vary from 1459 μGyy^{-1} to 2765 μGyy^{-1} with the average of 2141 μGyy^{-1}. Fig. 2 depicts the frequency of occurrence of the range of the values obtained in the series of measurements of natural background gamma radiation at various locations in the study area. Frequency of occurrence of recorded values under the interval of 260 μGyy^{-1} almost obeys normal distribution. The range of recorded values of gamma data is quantified from 1719 μGyy^{-1} to 2499 μGyy^{-1} is about 82% of the total number of measurements in the study area.

The locations are categorized into 5 different zones based on the present utilization; i. Cement mixing point (S01 to S11), ii. Sand storage point (S12 to S18) where the sand for construction is stored, iii. Granite storage point (S19 to S28) where granite is stored, iv. Stone crushing point (S29 to S42) where heavy stones are being crushed into small granite pieces for construction, v. other points (S43 to S65) where buildings of various sections of chemical plantation are being built. The parameters of estimation for gamma radiation levels like number of measurements, range of measurements and standard deviation made at each sample zone under study area are given in Table 2.

The average natural background gamma levels at different zones in proposed study area are shown in the Fig. 3. The elevated mean environmental radiation levels were found to be 2529 μGyy^{-1} at the sample location zone of stone crushing point. The elevated levels of gamma radiation, recorded in this zone, can be due to environmental gamma dose rate significantly contributed by the contamination of the dust particles produced in the process of crushing the granite stones with radionuclides. The decrease in the density of dust particles spreading away in the air flow may attribute to the significant variation of environmental gamma dose rate from the point of crushing. This result is in consistence with the one observed elsewhere (Tejado et al. 2016, Silvana et al. 2018). The elevated natural background radiation

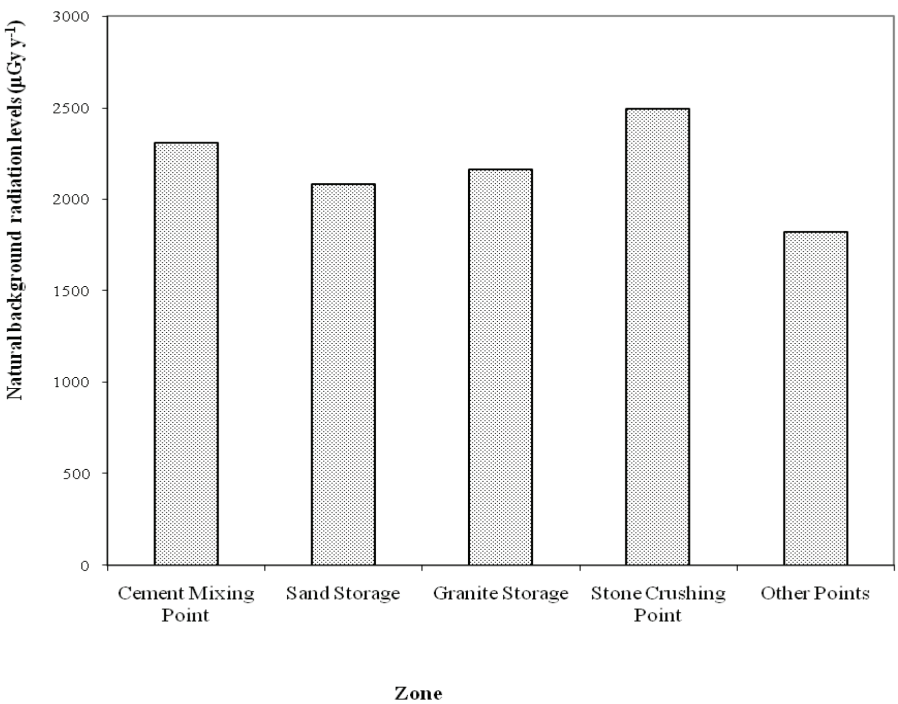

Fig. 3: Variation of natural background radiation levels at different zones.

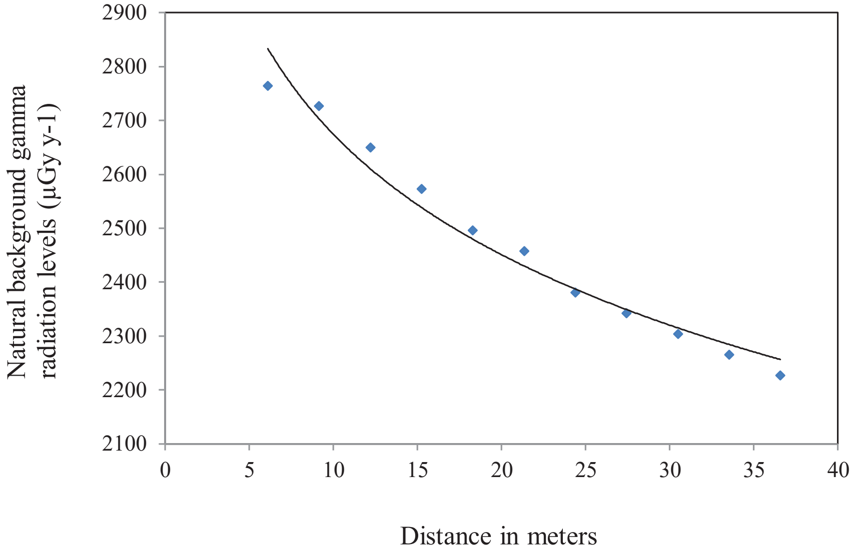

Fig. 4: Variation of natural background gamma radiation levels with distance from stone crushing point.

levels at cement mixing point can be attributed to the fly ash, which is the hoist for the elevated concentrations of natural radioactive elements.

A modest attempt has been made to see the variation of natural background radiation levels at different distances from the stone crushing point. Fig. 4 represents the variation of natural background radiation levels at different distances from stone crushing point. It depicts that the natural background radiation levels decrease as the distance increases. This indicates that the radiation levels were observed to be elevated at stone crushing point.

CONCLUSIONS

The variations of environmental gamma activity at a considerable level can be expected to be influenced by the various plant operations that involve in producing the petrochemical products. The gamma activity levels quantified in the present investigation can be a baseline data, which is of most significance to be considered in the process of establishment and construction of a plant of producing petrochemical products. The analysis of data established in the investigation is significantly useful information that can be considered in executing the further steps for the mitigation of environmental gamma dose at the time of the actual product activities being carried out in plant. In fact, the impact of meteorological conditions in the study area are not completely interpreted and quantified. It is necessary to explore the consideration of building characteristics and meteorological parameters through further investigation.

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