Preliminary Results of Radiological Impact Studies on the Usage of Granites in Hyderabad, Telangana State, India

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Abstract  Natural background gamma radiation levels were measured using a NaI crystal based survey meter in different type’s granite slab environs. These levels are found to vary between 2015 µGy y⁻¹ and 2716 µGy y⁻¹ with an average of 2270 µGy y⁻¹. This study establishes that usage of the granites as a flooring material in the building construction industry in the city like Hyderabad may not pose any additional radiation burden on the population.

Keywords  Natural Background Gamma Radiation Levels, Granites, Hyderabad

1. Introduction

Radiation has always been present on the earth and is a part of our natural environment. Humans have been exposed to radiation from natural sources since the dawn of time. About 82% of total human exposure to radiation is from natural sources, man-made sources such as medical exposures, phosphate fertilizers and consumer products etc. add about 18% to the total exposure, which is known as technologically enhanced natural radioactivity [1 and 2]. Exposures from natural sources are due to (a) external sources of extra-terrestrial origin (cosmic rays), (b) sources of terrestrial origin (radioactive nuclides present in earth’s crust, in atmosphere and in building materials), (c) internal exposure from radio nuclides taken into the body through ingestion of food materials, etc., and (d) indoor inhalation exposures due to radon (²²²Rn), thoron (²²⁰Rn) and their daughter products. These exposures vary depending on the location and elevated levels of naturally occurring radioactive substances like uranium (²³⁸U), thorium (²³²Th) and potassium (⁴⁰K) in specific localized areas. All exposures except those from the direct cosmic radiation are produced by the radioactivity of the radionuclides present in the environment [3 and 4]. Table 1 gives the radiation exposures to Indian population from different natural sources and its comparison with the reported global values.

The external exposures in indoors is largely due to the presence of radionuclides in the building materials used for the construction of dwellings. Surveys show that the exposure values are lower in wood-frame houses, in the countries such as New Zealand, Iceland and United States whereas higher values are in stone/masonry buildings of Portugal, Australia, Italy, Sweden, Iran and China [6].

| Radiation Sources      | India: Annual Effective dose (mSv⁻¹) | Percent contribution | World: Annual Effective dose (mSv⁻¹) | Percent contribution |
|------------------------|-------------------------------------|---------------------|-------------------------------------|---------------------|
| **External:**          |                                      |                     |                                     |                     |
| Cosmic radiation       | 0.355                               | 15.44               | 0.380                               | 16.14               |
| Terrestrial            | 0.379                               | 16.48               | 0.480                               | 19.55               |
| **Internal:**          |                                      |                     |                                     |                     |
| Cosmogenic nuclide     | 0.015                               | 0.65                | 0.010                               | 0.41                |
| ²²²Rn and ²²⁰Rn        | 1.235                               | 53.72               | 1.275                               | 51.94               |
| Terrestrial            | 0.315                               | 13.70               | 0.310                               | 12.63               |
| Total (Rounded off)    | 2.30                                | 100.0               | 2.5                                 | 100.0               |
In larger structures, the building materials may contribute a greater share to the indoor concentration, but the absolute contribution is usually small. However, certain materials have been found to constitute unusually large sources of radon, and in such cases, the building materials may be the source of unacceptably high indoor radon concentrations. Concretes made from aggregates of granite, pumice and shale have among the highest reported radon emanation rates while wood has a particularly low $^{226}\text{Ra}$ concentration and is a negligible source of indoor radon. The use in building and construction materials of industrial solid wastes that contain technologically enhanced concentrations of $^{226}\text{Ra}$ is a contributing source to high radon concentrations indoors. Fly ash from coal-fired power plants is used as an additive in cement and by-product gypsum from the phosphate industry is utilized in plasterboards and in concrete. These wastes contain a higher than average concentration of radium, and in some cases, such building materials are a significant source of indoor radon. The natural radioactivity content in some building materials and by-products frequently used in the building industry in India are shown in Table 2.

Table 2. Natural radioactivity content in some building materials and by-products frequently used in the building industry in India [7].

| Materials used       | $^{40}\text{K}$ (Bq kg$^{-1}$) | $^{226}\text{Ra}$ (Bq kg$^{-1}$) | $^{232}\text{Th}$ (Bq kg$^{-1}$) |
|----------------------|-------------------------------|---------------------------------|---------------------------------|
| Cuddapah tile        | 253                           | 10                              | 22                              |
| Mosaic tile          | 72                            | 11                              | 6                               |
| Grey-black granite   | 820                           | 93                              | 103                             |
| Black granite        | 76                            | 6                               | 9                               |
| Sandstone            | 439                           | 11                              | 12                              |
| Marble               | <0.67                         | 6                               | <0.40                           |
| Large stone chips    | 136                           | 6                               | 5                               |
| Small stone chips    | 120                           | 7                               | 9                               |
| Sand                 | 464                           | 18                              | 46                              |
| Bricks               | 186                           | 21                              | 28                              |
| Cement               | 133                           | 39                              | 27                              |
| PoP                  | 398                           | 22                              | 42                              |
| Concrete             | 180                           | 15                              | 17                              |
| Soil                 | 170                           | 9                               | 14                              |

In India, the terrestrial radiation profile has been prepared from the geological data by Sankaran et al., [8]. According to this, the granitic rocks and gneisses occupy major portions in the state of Telangana. A countrywide sample survey of outdoor natural background radiation levels has been carried out by earlier researchers [9]. It was reported that the average natural background radiation levels per caput is higher in this region. A national level coordinated research project to study the radioactivity levels has been initiated by the Board of Research in Nuclear Sciences of Department of Atomic Energy (BRNS-DAE). As a part of this project, the radioactivity levels in dwellings of Hyderabad, Ranga Reddy and Khammam district has been carried out. Part of the Nalgonda district is also covered for the estimation of natural background radiation levels by our group [10]. The results of these studies reveal that the natural background radiation levels are elevated in this region of Telangana state, India.

Hyderabad is one of the fast growing metropolitan cities in India. Due to the rapid urbanization a variety building materials have been using for the construction of buildings both for residential and commercial. Our research group has planned to study the radiation levels from different building materials used in the construction industry in Hyderabad city. As a part of it, it is learnt that a large amount of granites stones are using for the construction of buildings. Most of these granites are derived from the quarries of Southern India and on brand names like Pokarna, Suguna etc. Present paper deals with the preliminary investigation for the natural background radiation levels from different kinds of granite slabs used in Hyderabad city.

2. Materials and Methods

Natural background gamma radiation levels were measured using a NaI(Tl) crystal based $\mu$R-survey meter, M/s. Nucleonix Systems Private Limited, Hyderabad make for about 75 granite samples obtained from various suppliers with different trade names like Pokarna, Suguna, etc. Natural background gamma radiation levels were measured by bringing the granite slab very close in contact with the survey meter in a room on a wooden table of height about 1meter. Care has taken while using survey meter for one sample by keeping other granite samples far away from the table to minimize their influence. Our previous studies established that the natural background radiation levels estimated using survey meter and the thermoluminescence dosimeters (TLDs) in indoors are at good agreement (shown in Fig.1), with the correlation coefficient of about 0.9 [11].

Figure 1. Correlation between the measurements of Survey meter and TLD technique (values in $\mu$Gy y$^{-1}$)

3. Results and Discussion

Natural background gamma radiation levels measured in...
the vicinity of different granite slabs is shown in Table 3. The natural background radiation levels are found to vary between 2015 $\mu$Gy y$^{-1}$ and 2716 $\mu$Gy y$^{-1}$ with an average of 2270 $\mu$Gy y$^{-1}$. The Natural background radiation levels measured using the same survey meter on the same table without any granite slabs in the vicinity is found to be 2102 $\mu$Gy y$^{-1}$, which is considered as a control.

The average value of Natural background radiation levels measured by keeping the granite slabs in contact with the survey meter is not varying significantly from the control except in one case. This establishes that the usage of these granites as a flooring material in the building construction industry in the city like Hyderabad may not pose any additional radiation burden on the population. However, the conclusion can be more effective when one studies the samples for the evaluation of U, Th and K-40 concentrations and exhalation rates; such an attempt is under progress.

Table 3. Natural background radiation levels ($\mu$Gy y$^{-1}$) with different granite slabs.

| S.No. | Trade Name                  | Natural background gamma radiation levels | S.No. | Trade Name                  | Natural background gamma radiation levels |
|-------|-----------------------------|------------------------------------------|-------|-----------------------------|------------------------------------------|
| 1     | Blue Antique               | 2102                                     | 39    | Pokarna Tan Brown           | 2234                                     |
| 2     | Blue Pearl                 | 2059                                     | 40    | Siberian White              | 2365                                     |
| 3     | Brown Antique (ND Van)     | 2234                                     | 41    | Silver Pearl-1              | 2234                                     |
| 4     | Brown Antique (Van)        | 2146                                     | 42    | Silver Pearl-2              | 2190                                     |
| 5     | Dragon Red                 | 2146                                     | 43    | Silver Pearl Carres         | 2409                                     |
| 6     | Dragon Red Leather         | 2365                                     | 44    | Silver Pearl Flamed         | 2190                                     |
| 7     | Emerald Pearl              | 2409                                     | 45    | Silver Pearl Leather        | 2321                                     |
| 8     | Faizal                      | 2190                                     | 46    | Silver Waves Brushed        | 2190                                     |
| 9     | Flash Blue Care            | 2190                                     | 47    | Silver Waves Carres         | 2146                                     |
| 10    | Flash Blue Flamed          | 2278                                     | 48    | Silver Waves Honed          | 2321                                     |
| 11    | Flash Blue Honed           | 2409                                     | 49    | Silver Waves Leather        | 2278                                     |
| 12    | Flash Blue Leather         | 2321                                     | 50    | Silver Waves Polished       | 2453                                     |
| 13    | Flash Blue Polished        | 2278                                     | 51    | Stonex India Atlantic Beige | 2190                                     |
| 14    | Gold Dots Dark             | 2190                                     | 52    | Stonex India Bronz          | 2059                                     |
| 15    | Golden Dream               | 2190                                     | 53    | Stonex Orani Beige          | 2102                                     |
| 16    | Golden Dream Polished      | 2278                                     | 54    | Suguna Amanii Brown         | 2102                                     |
| 17    | Hail Storm Flamed          | 2321                                     | 55    | Suguna Bofichino Classiccio | 2146                                     |
| 18    | Hail Storm Leather         | 2540                                     | 56    | Suguna Bracia Dyna          | 2234                                     |
| 19    | Hail Storm Polished        | 2497                                     | 57    | Suguna Crema Fantasy        | 2102                                     |
| 20    | Ikon white                 | 2365                                     | 58    | Suguna Crema Beige          | 2059                                     |
| 21    | Mini Green Leather         | 2321                                     | 59    | Suguna Marvo World RL       | 2190                                     |
| 22    | Mini Green                 | 2321                                     | 60    | Suguna Perlato Sicilia      | 2102                                     |
| 23    | Mini Green Polished        | 2365                                     | 61    | Sun Surf Green Brushed      | 2190                                     |
| 24    | Mint Green Brushed         | 2409                                     | 62    | Sun Surf Green Polished     | 2321                                     |
| 25    | Mint Green Carres          | 2453                                     | 63    | Sun Surf Green Honed        | 2059                                     |
| 26    | Mint Green Honed           | 2409                                     | 64    | Sun Surf Green Leather      | 2102                                     |
| 27    | Moon White 1               | 2453                                     | 65    | Tan Brown-1                 | 2278                                     |
| 28    | Moon White 2               | 2321                                     | 66    | Tan Brown-2                 | 2321                                     |
| 29    | Moon white Flamed          | 2409                                     | 67    | Tropical Green Brushed      | 2321                                     |
| 30    | Moon White Leather         | 2278                                     | 68    | Tropical Green Flamed       | 2278                                     |
| 31    | XX Pink                    | 2716                                     | 69    | Tropical Green Honed        | 2102                                     |
| 32    | XX Purple dots             | 2015                                     | 70    | Tropical Green Leather      | 2278                                     |
| 33    | Pokarna Green Brushed      | 2540                                     | 71    | Viscount White              | 2321                                     |
| 34    | Pokarna Green Carres       | 2234                                     | 72    | Viscount White Flamed-1     | 2409                                     |
| 35    | Pokarna Green Flamed       | 2190                                     | 73    | Viscount White Flamed-2     | 2234                                     |
| 36    | Pokarna Green Honed        | 2321                                     | 74    | Minimum                     | 2015                                     |
| 37    | Pokarna Green Leather      | 2365                                     | 75    | Maximum                     | 2716                                     |
| 38    | Pokarna Green Polished     | 2234                                     |       | Average                     | 2270                                     |
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REFERENCES

[1] Gesell, T.F., Prichard, H.M. The technologically enhanced natural radiation environment. Health Phys. 28, 361-366, 1975.

[2] Mishra, U.C., Ramachandran, T.V. Technologically enhanced natural radiation sources: A review. Bull. Radiat. Prot. 11, 270-280, 1988.

[3] Rangarajan, C., Gopalakrishnan, S., Sadasivan, S. Monograph on Radioactivity of the Environment, Indian Nuclear Society, Mumbai, 2002.

[4] Subba Ramu, M.C. Natural Background Radiation and Population Exposures. BARC Report No. BARC/1993/R/012, 1993.

[5] Puranik, V.D., Ramachandran, T.V. Natural and man-made environmental background radiation exposure levels: A review. Environ. Geochem. 8, 60-74, 2005.

[6] UNSCEAR, 2000 United Nations Scientific Committee on the Effects of Atomic Radiation, Ionising radiation: Sources and Biological Effects, United Nations, New York, 2000.

[7] Ramola, R.C., Rawat, R.B.S., Kandari, M.S., Ramachandran, T.V., Choubey, V.M. Measurement of indoor radon levels around Uttarkashi and Pauri Garhwal areas using nuclear track detector techniques. Indian J. Environ. Prot. 17, 519-526, 1996.

[8] Sankaran, A.V., Jayaswal, B., Nambi, K.S.V., Sunta C.M. U, Th, and K distributions inferred from regional geology and the terrestrial radiation profiles in India, Tech. Report, Bhabha Atomic Research Centre, Mumbai, India, 1986.

[9] Nambi, K.S.V., Bapat, V.N., David, M., Sundaram, V.K., Sunta, C.M., Soman, S.D., 1986. Natural background radiation and population dose distribution in India. Tech. Report, Bhabha Atomic Research Centre, Mumbai, India.

[10] Vinay Kumar Reddy, K., Sreenivasa Reddy, B., Sreenath Reddy, M., Gopal Reddy, Ch., Yadagiri Reddy, P., Rama Reddy, K. Natural radioactivity levels in some villages near Nagarjuna Sagar, Nalgonda, Andhra Pradesh. Radiat. Prot. Environ. 26, 488-491, 2003.

[11] Sreenivasa Reddy, B., M., Gopal Reddy, Ch., Yadagiri Reddy, P., Rama Reddy, K. Estimation of natural background gamma radiation levels in dwellings of Khammam district, Andhra Pradesh, India. Radiat. Prot. Environ. 28, 301-303, 2005.