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ENVIRONMENTAL GAMMA DOSE MEASUREMENTS IN THE CITY OF LAHORE, PAKISTAN

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Environmental gamma radiation levels in Lahore city were measured using the radiation monitor which employs G. M tube. Average absorbed dose rate in air varied from 140 nGy h^{-1} to 282 nGy h^{-1} with the mean value of 197 nGy h^{-1}. The effective dose rate levels in Lahore city were found in the range of 860±147 μSv y^{-1} to 1732 ±187 μSv y^{-1} with the mean value of 1208 ±244 μSv y^{-1}, whereas annual average effective dose equivalent due to terrestrial component only is 275 μSv. The collective effective dose equivalent to the population in the city is 1432 man.Sv. y^{-1}. These radiological doses are not posing any significant health hazards.

Keywords: Environmental radiation, Gamma radiation, Radiation monitoring, Gamma dose, Lahore.

1. Introduction

The city of Lahore is the capital of Punjab province. It is a metropolitan city covering an area of about 400 km^2 with a population of over 5.2 million. It is situated at 31^0 34/ North and 74^0 19/ East with 216 m altitude [1]. The city is built in the form of a parallelogram, the area within the old city walls, exclusive of the citadel, being about 1.87 km^2. It stands on the alluvial plain traversed by the river Ravi. The river, makes a very circuitous bend from the east, passes in a semicircle to the north of Lahore. The city is slightly elevated above the plain, and has a high ridge within it, running east to west on its northern side. The whole of this elevated ground is composed of the accumulated debris of many centuries.

When the earth was formed over a billion years ago, the materials from which it was made contained radioactive elements. About 70 radionuclides have been found in nature [2]. These can be divided into two main categories. Cosmogenic radionuclides produced by cosmic rays e.g. ^3H, ^7Be, ^{14}C etc and primordial radionuclides, which are of two types, singly occurring radionuclides with long half lives e.g. ^{40}K, ^{87}Rb, found in all rocks, soil, water and living organism even the humans and members of the families of radioactive heavy elements produced in ^{238}U, ^{235}U and ^{232}Th decay series [3]. The concentration of these elements varies considerably depending on the type of rock and/or soil formation. The concentration of ^{40}K, ^{226}Ra and ^{232}Th has been reported in the literature [4]. In sandstone and limestone regions their concentration is much lower than in granite. Cosmic rays are more intense at higher altitude. Thus the dose rate also depends upon the geographic location.

In the present study a comparison of outdoor radiation levels of old (walled) and new city of Lahore are presented. The results are also compared with some other cities. The aim of this study is to determine the environmental gamma background radiation levels including cosmic gamma contribution with the help of a radiation survey meter in the first step and then to extend the study to other cities of Pakistan in order to develop a reference data for background doses. The results of the study are expected to provide a baseline data for the purpose of comparative monitoring after any nuclear event/accident locally or from across the boundaries of Pakistan.

2. Materials and Methods

The monitoring was carried out by using the radiation surveymeter, FAG, model FH40F4, employing a G. M. tube, which has energy independent response from 45 keV to 1.3 MeV and

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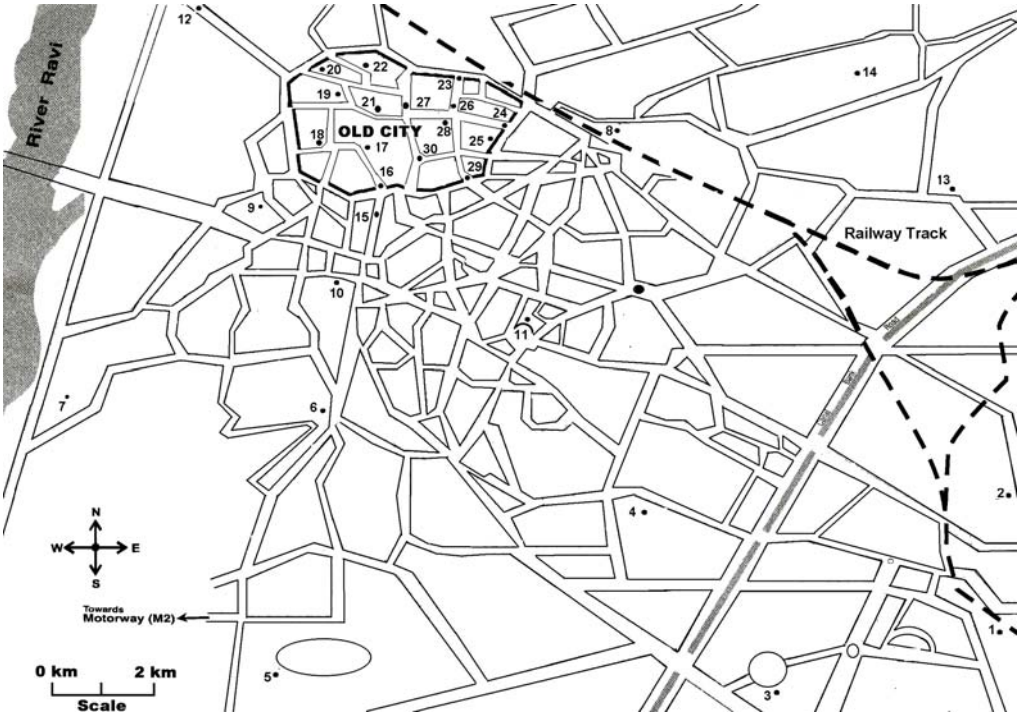

Figure 1. Thirty different locations of terrestrial gamma radiation measurements in Lahore city.

measuring range of mR h^{-1} to 999 mR h^{-1} (100 μGy h^{-1} to 999 99.9 Gy h^{-1}). Measurement by FAG surveymeter owing to its instantaneous results and easily portable nature with almost nil transport charges was preferred over TLD technique which requires longer exposure times (in months) to record background radiation levels and thereafter requires indirect evaluation of the results in the laboratory. The reliability of the surveymeter results was ensured through its calibration in the Secondary Standard Dosimetry Laboratory (SSDL), PINSTECH, Pakistan, whose measurements is traceable to the Primary Standard, National Physics Laboratory (NLP), London and are ensured by the International Atomic Energy Agency (IAEA). The measurements were conducted during the period May-July, 2002 and made at a reference height of 1 meter above the ground level in open air. To cover the whole city 30 suitable points were chosen as shown in Fig. 1. Ten to twenty measurements were taken at each location and their mean value was converted to absorbed dose in air (nGy h^{-1}). Minimum, maximum and mean value of absorbed dose rate in air, effective dose rate and dose equivalent are mentioned in Table 1.

3. Results and Discussion

The absorbed dose rate (including cosmic ray contribution) in air in Lahore city has been found to vary from 140 nGy h^{-1} to 282 nGy h^{-1} with a mean value of 197 nGy h^{-1}. Effective dose rates in the new city are ranging from 860$\pm$147 μSv y^{-1} to 1628$\pm$103 μSv y^{-1} with a mean value of 1060$\pm$198 μSv y^{-1} whereas in the old (walled) city these values range from 1107$\pm$161 μSv y^{-1} to 1732$\pm$187 μSv y^{-1} with a mean value of 1355$\pm$194 μSv y^{-1} The effective dose rate of whole Lahore city range from 860 μSv y^{-1} to 1732 μSv y^{-1} with an over all mean value of 1208 $\pm$244 μSv y^{-1}. The dose rates measured in new and old city of Lahore are compared.

Gamma ray activity elsewhere in the building materials of Lahore city has already been measured [4]. To reconfirm that the building materials in Lahore do contribute significantly to terrestrial gamma dose, a number of measurements were conducted in the open area of cricket stadium, where the contribution from the buildings is negligible (the distance from the nearest building is about 250 m). The average environmental gamma dose rate obtained at this location is 860$\pm$147 μSv y^{-1}. Comparing mean

Table 1. Environmental gamma radiation levels in Lahore city-Pakistan.

Location	Absorbed dose rate in air		Effective Dose Rate (μSv y^{-1})	Effective Equivalent Dose (μSv y^{-1})
	Average	Range		
New City				
Ghalib Market, Gulberg	174	104-228	1069±254	233
Fortress Stadium	155	107-204	951±257	198
Cricket Stadium	140	109-166	860±147	171
Services Hospital	156	119-193	957±192	200
Gulshan-e-Iqbal	152	122-184	933±205	192
Chuburgy, Multan Road	152	120-195	931±177	192
Sanda Road	188	142-225	1151±192	258
Railway station	163	133-194	999±173	212
Bilal Ganj	143	88-187	876±275	176
Lahore Museum	148	109-185	909±225	185
Assembly Hall	169	156-186	1035±115	223
Ravi Road	203	141-223	1243±265	285
Mughal Pura	188	172-210	1151±134	258
Engineering University	266	255-290	1628±103	401
Anarkali Bazaar	196	166-221	1204±153	274
Old (Walled) City				
Lohari Gate	220	208-247	1351±179	318
Chauk Jhanda	229	211-250	1402±149	333
Said Mittha Bazaar	214	199-220	1313±78	307
Tibbi Thana	186	156-204	1143±157	255
Badshahi Masjid	212	201-226	1299±82	302
Roshnai Gate	217	190-253	1329±228	312
Lahore Fort	276	221-314	1694±227	421
Sheranwala Gate	270	246-300	1659±176	410
Yakki Gate	220	189-260	1351±221	318
Dehli Gate Bazaar	282	246-323	1732±187	432
Masjid Wazir Khan	194	165-222	1190±146	270
Kashmiri Bazaar	180	158-208	1107±161	245
Sooha Bazaar	206	164-247	1262±254	291
Shah Alami Gate	211	194-221	1295±77	301
Gumti Bazaar	197	160-221	1206±187	274
Minimum	140		860±147	171
Maximum	282		1732±187	432
Average	197±40		1208±244	275±49

dose rate of 1355±194 μSv y^{-1} and 1060±198 μSv y^{-1} found in old and new city respectively with dose rate found in the stadium. It is clear that maximum contribution from building materials of old and new city in the environmental gamma dose rate of Lahore city is 36% and 19% respectively.

The slightly higher background levels of old Lahore city is due to the populous and congested areas, involving lot of building materials and radon concentration [5]. The multistorey houses in the old city have very thick structures and are built on debris of centuries old construction materials. On

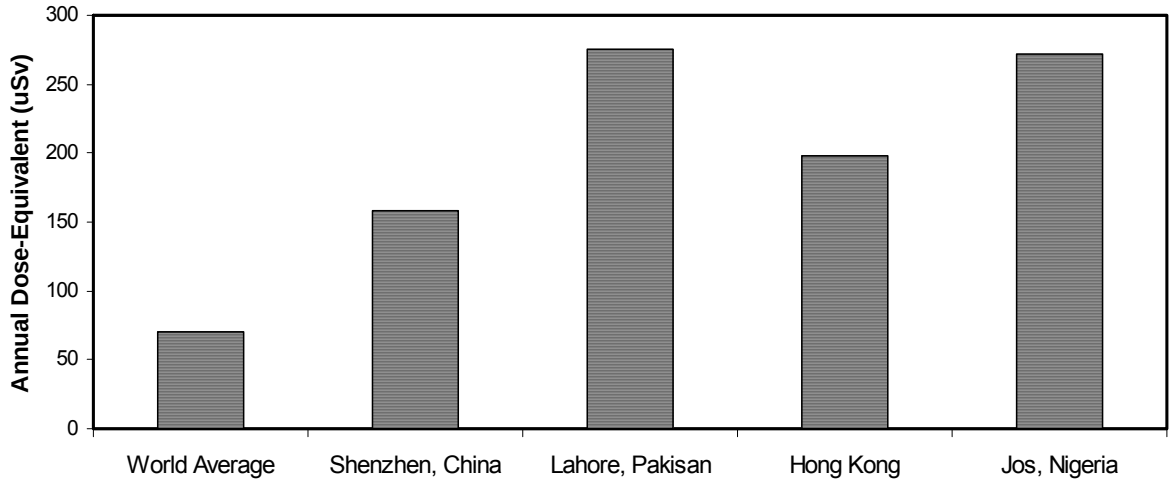

Figure 2. Comparison of average terrestrial gamma dose equivalent of Lahore City with different cities of the world

the other hand, the new city has thin modern structures and hence less building materials are used. These houses have good ventilation system and are spread over larger areas with open and wide streets and roads, resulting in dilution of radon.

The contribution from cosmogenic radionuclides at an altitude of 216 m above the sea level of Lahore city to the present environmental gamma background radiation level has been calculated using method described by Marshal [6] and was found to be 291 μSv y^{-1}, this is relatively small as compared to the average annual external gamma background radiation exposure of 1208 μSv y^{-1} in Lahore.

The mean contribution to the annual external effective dose equivalent due to natural exposure to human from ionizing radiation from the external terrestrial radiation, ^{40}K and decay products of ^{238}U and ^{232}Th with outdoor occupancy factor of 0.3 [7] and neglecting the cosmogenic contribution of 291 μSv y^{-1} in the mean effective dose of 1208 μSv y^{-1}, in Lahore city comes out to be 275 μSv y^{-1}.

Similar studies were also carried out in different cities of the world i.e. Shenzhen, (China), Jos, (Nigeria) and Hong Kong, which reveal annual effective dose equivalent of 158 μSv [8], 198 μSv [9] and 272 μSv [10] respectively. The annual world average effective dose equivalent has been reported as 70 μSv [11]. Annual effective dose equivalent of Lahore city is higher as compared to the world average, Shenzhen, (China), Jos, (Nigeria) and Hong Kong as shown in Fig. 2.

The collective effective dose equivalent was assessed according to ICRP Publication 60 [12] by using the following relation;

$$S_E = H.N \quad (1)$$

where S_E is the collective effective dose equivalent, H is the average annual effective dose equivalent per individual and N is the number of individuals. Using the census figure of 1998, which gives N as 5,209,088 for Lahore city [13] the collective effective dose equivalent in the city is 1432 *man.Sv.*y^{-1}.

4. Conclusions

Environmental background radiation levels of old Lahore city are higher as compared to the new city of Lahore. Average effective dose equivalent of whole Lahore city is higher as compared to the worldwide values but not so high as to produce any significant radiation hazard to the population concerned.

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