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Radon measurement studies in workplace buildings of the Rawalpindi region and Islamabad Capital area, Pakistan

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ABSTRACT

A survey concerning measurement of the indoor radon levels has been carried out in 105 workplaces of the Rawalpindi region and Islamabad Capital Territory using CR-39 based radon detectors. The main objective of this study was to assess the health hazard due to the indoor radon. CR-39 based NRPB type detectors were installed in offices/rooms located on first floors, ground floors and basements and were exposed to indoor radon for six months. The measured indoor radon concentration in the buildings surveyed ranged from 12 ± 5 to 293 ± 19 Bq m^{-3} with an overall mean value of 64 ± 32 Bq m^{-3}. The highest mean radon concentration (113 ± 48 Bq m^{-3}) was observed in the offices located in basements of the Rawalpindi city. The overall average annual effective dose in the studied workplaces was estimated to be 0.61 ± 0.30 mSv. The mean annual effective doses in basements, ground floor and first floor were found to be 0.87 ± 0.34 mSv, 0.55 ± 0.28 mSv, and 0.47 ± 0.29 mSv, respectively. These values are less than the action level recommended by International Commission on Radiological Protection.

1. Introduction

Radon is an inert radioactive gas which arises from the decay chain of uranium. The major sources of indoor radon include: building materials (e.g. cements, ceramics, marble chips, etc.), water, energy sources and geological structures underneath the built-up area. The production rate of indoor radon depends upon the concentration of radium in the subsoil, the materials used in the construction of rooms, and the porosity as well as the density of the wall material [1–5]. The other factors affecting the concentration of indoor radon are the surrounding climate and the building engineering. Therefore, the design of a building, the ventilation system, the heating and cooling system, the sanitary fittings, etc. play an important role in radon accumulation inside the buildings. ^{222}Rn is emanated from soil and rock, which is the main source of ^{222}Rn to the atmosphere. Atmospheric ^{222}Rn concentration, therefore, depends on the emanation power of the ground and advection/diffusion in the air [6–12].

Measurement of the indoor radon is highly desirable because the radiation dose received by the human population due to the inhalation of radon and its progeny contribute more than 50% of the total dose from natural sources [13–15]. Recent experimental and epidemiological studies suggest that inhalation of radon progeny, which are the most important source of irradiation of the human respiratory track in workplace and domestic environment could be a cause of lung cancer [16]. In this context, quantification of individual radon exposure over a long time period is one of the main issues. The source and concentration level of ^{222}Rn, as well as its effects on human health, have been extensively reported in the literature (see, for example UNSCEAR, 2000 and references quoted there in). The variable distribution of radon inside the built-up environment has been the subject of worldwide interest to identify and reduce its levels because due to its carcinogen effects [17–21]. High radon exposures have been shown to cause lung cancer and it is widely believed that the greater the exposure to radon, greater would be the risk of developing lung cancer [22,23].

Studied districts located in the northern part of the Punjab Province, Pakistan, are shown in Fig. 1. The studied area is one of the most densely populated areas of Pakistan. It contains the ancient city of Rawalpindi and the new national capital, Islamabad. Its varied landscape is constantly affected by erosion. It is situated between 33°9′ north latitude and 73°13′ east longitude. The elevations of the surveyed area are generally between 300 and 600 m [24–26].

All the buildings surveyed in the Rawalpindi region and Islamabad Capital Territory were built from baked bricks, sand and

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Fig. 1. Map showing the studied area of four districts of the Punjab Province and Islamabad Capital Territory.

cement. These included both single and multistorey buildings. The buildings were detached and semi-detached types. The studied workplaces included markets, restaurants, entertainment places, hospitals, factories, government and private offices/buildings, etc.

The main objective of this study was to measure indoor radon levels in four districts of the Punjab Province and Islamabad Capital Territory. This study is a part of nationwide survey and measurement of indoor radon levels in workplace buildings, so far, not been conducted in Pakistan.

2. Materials and methods

A total number of 105 workplaces (government and private offices/buildings, marriage centers, community halls, markets, restaurants, entertainment places, hospitals, etc.) were surveyed for indoor radon workplace measurements in the Rawalpindi region and Islamabad Capital area. CR-39 based NRPB detectors were used in this study. In this regard, large sheets of CR-39 having 500 μm thickness, supplied by the Page Mouldings, Ltd., UK, were cut into small pieces of size 2 cm × 2 cm. From these detectors, some samples were kept in the refrigerator for background purposes. The remaining detectors were then placed in the dosimeters of National Radiological Protection Board (UK) now called the Radiation Protection Division of the Health Protection Agency (HPA) for these measurements. These dosimeters were calibrated at NRPB and corresponding calibration factor was used [27]. CR-39 based NRPB detectors were then installed in 345 rooms which included 45 rooms (13%) in

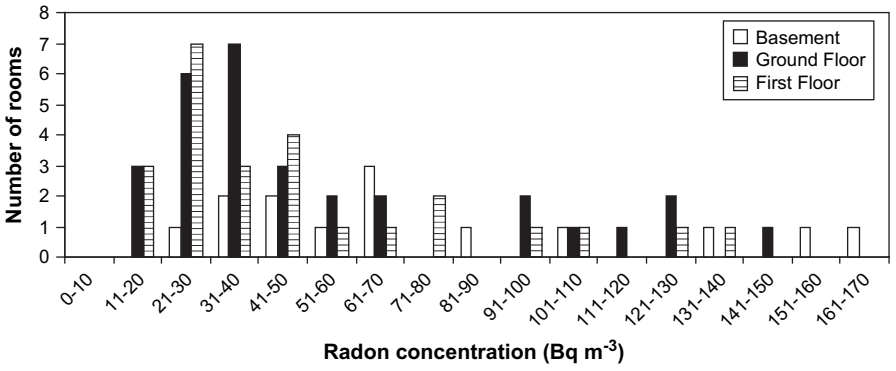

Fig. 2. Distribution of radon concentration measured in workplaces in Islamabad Capital Territory.