DETECTION OF RADON PRODUCTS IN ATMOSPHERE AND ITS CONCENTRATION

Thesis

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Presented by

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To

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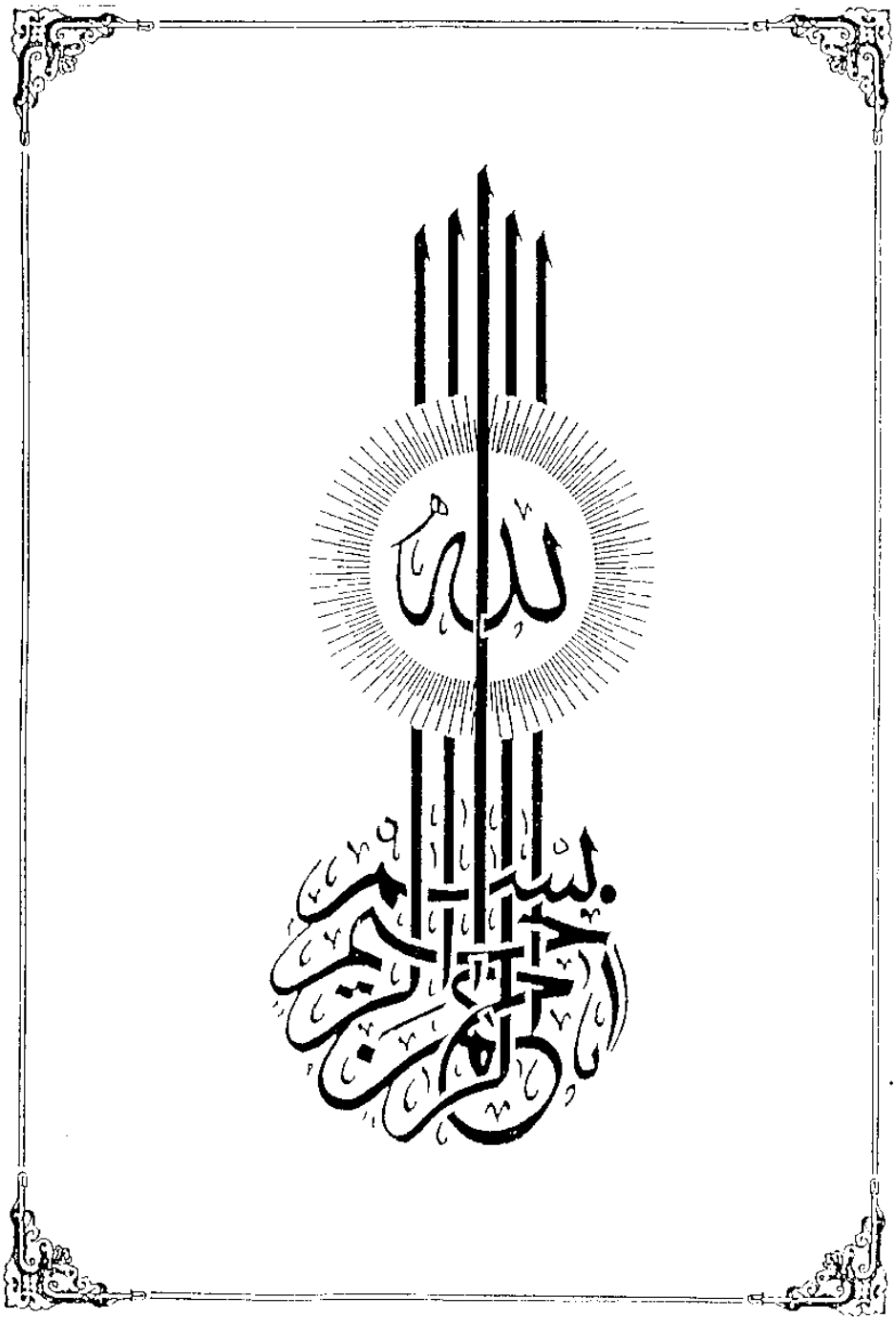
TO MY FAMILY FOR THEIR MORAL SUPPORT

WITH MY SINCERE THANKS AND DEVOTION



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Contents

CHAPTER 3

Introduction

In recent years, public and national authorities in many countries have shown a great interest in measuring and controlling the natural radioactivity in the environment. The average dose received from radiations resulting from the decay of radon gas and its daughters is believed to be larger than the sum of doses received from all other natural and man-made sources of radiations.

Because of energy crises, compact energy saving houses and buildings became very common in most countries with very cold and/or very warm climates. These houses and buildings usually have limited ventilation causing considerable accumulation of radon gas in their environment.

Because of the well-established relationship between lung cancer and high radon concentration, indoor radon concentration is today subject to regulations in many countries.

There are three radon isotopes (^{219}Rn, ^{220}Rn, ^{222}Rn) in nature, resulting from the decay of the well-known three naturally occurring radioactive series. Since the element is chemically inert, it has the ability to migrate from its sources without any chemical reactions.

The half-life of ^{219}Rn is 3.96 s, that of ^{220}Rn is 55.6 s, and that of ^{222}Rn is 3.82 days. Owing to the short half-life of the first two isotopes, only ^{222}Rn can migrate a significant distance from its source and constitute the major part of the dose caused by radon gas. According to this fact, the present work will deal only with ^{222}Rn isotope .

The climate of the State of Qatar is very warm during the summer and also for considerable parts of the spring and autumn. Energy-tight houses and buildings with air conditioning working day and night for several months are very common. Consequently, the problem of accumulation of indoor radon may exist. No measurements of radon concentration in Qatar have been performed before.

The aim of the present work is to implement a suitable technique to measure radon concentration in Qatari houses and buildings. As a first stage, it was found reasonable to start with a technique to evaluate the short-term average indoor radon concentration. The activated charcoal method was chosen to perform this evaluation.

Although many of the building materials used in Qatar are imported, without controlling the content of natural radioactivity, the geology of Qatar is known to be free from a high concentration of radioactive sediments. Therefore, it is most probable that the concentration of

radon will be low. Consequently, great effort has been put into the present work towards the improvement of the technique. The improvement is guided towards increasing the accuracy, as well as the sensitivity, of the method to decrease its minimum detectable concentration. Using the improved technique, a limited number of indoor radon concentration in some Qatari houses was measured.

Summary

The present work is represented in three chapters. The first includes a brief survey of radon gas sources, decay products of its isotope ^{222}Rn, its hazards, and estimation of risk due to exposure to radiation emitted from the gas and its decay products.

The second chapter reviews the most important methods for detecting the gas. All these methods are based on the detection of alpha and/or gamma radiation emitted during the decay process. The detections are clarified according to their active or passive character. The methods reviewed are: Lucas cells, ionization chambers, two filter methods, semiconductor detectors, activated charcoal methods and, finally, solid state nuclear track detectors with their different configurations.

The third chapter is the main chapter. It includes detailed description of the technique used in the present work, how it improved and was used after improvement to measure radon concentration in some Qatari houses.

Since no measurements have been made before to measure radon concentration in Qatar, it was found reasonable to start with a technique to evaluate the short-term average indoor radon concentration. The activated charcoal method

was chosen for this purpose. This method is based on exposing a canister containing a known amount of activated charcoal for a few days to the environment. During exposure, the canister will absorb radon gas and humidity. After exposure, the canister is weighed to estimate the water gain, and then left for at least three hours to attain equilibrium between the absorbed radon and its gamma emitting daughters. After equilibrium, gamma spectrum from the canister are analyzed by a gamma spectrometer, the interests of gamma lines from ^{214}Pb and ^{214}B, radon daughters are measured. From these interests, the radon concentration in pCi/l can be deduced by using a suitable calibration factor. This calibration factor depends on the exposure time of the canister, as well as its water gain.

The present work followed the same procedures and conditions stated by the United States Environmental Protection Committee (EPA). Consequently, their calibration factors were used. Since the calibration factor depends on the exposure time as well as the water gain by canister, the EPA presented a curve for an exposure time equals two days. For other exposure times, the calibration factor should be adjusted by an adjusting factor depending on the humidity of the environment. Values for the adjusting factor are given by three curves for different humidity ranges.

In the present work, it was found convenient to gather and

represent all information of the calibration factor and adjusting factors in only one three dimensional curve. The curve will represent directly the adjusted calibration factors for different exposure times and water gain. This was done by a simple program executed on a personal computer and it can read directly the adjusted calibration factor at different exposure conditions.

Although many building materials used in Qatar are imported without control of their content of natural radioactivity, the geology of Qatar is known to be free from high concentration radioactive sediments. Therefore, it is most probable that the concentration of radon will be low. Consequently, great efforts have been made to improve the method, after its adaption, to the needs of the desired measurements.

The factors which brought improvements to the method can be summarized as follows:

A - Detector

A detailed study of the characteristics and performance of a hyper pure germanium and a scintillation gamma spectrometer was performed. The results indicated that the scintillation detector is the most suitable for the present study owing to its high detection efficiency. Its poor energy resolution is not a matter of concern.