

# Chapter I

## INTRODUCTION

### 1.1 Background and problems of interest

The risks to human health posed by ionizing radiation are well known. UNSCEAR [1] reports that the most important sources of ionizing radiation are radon and its decay products because they contribute about 50% of the annual dose received by population. Two isotopes of radon are more concerned for the hazard by inhalation. First is the  $^{222}\text{Rn}$  isotope that is commonly known as radon, which arises from the radioactive decay chain of uranium-238. Second is the  $^{220}\text{Rn}$  isotope that is usually called thoron, which arises from decay chain of thorium-232. Uranium and thorium are common elements in the earth's crust, rocks and soils. Some fraction of the radon and thoron produce in rocks and soils escape to air. Therefore, radon and thoron are present in the atmosphere. Radon and thoron progeny are generated in the atmosphere in two steps as follow;

I) The formation of their progeny from the radon and thoron gas by decay. The freshly generated radionuclides, mostly positively charged, are neutralized and become small particles called clusters through reaction with atmospheric trace gases and water vapor in air.

II) The cluster formation. These radionuclides attach to existing aerosol particles in the atmosphere within 1-100 s, forming radioactive aerosol of the radon and thoron progeny.

Thus, simply by breathing, people everywhere are exposed to radiation from radon, thoron and radioactive aerosol of their decay products.

When radon, thoron and radioactive aerosol of their decay products are inhaled, densely ionizing alpha particles emitted by deposited short-lived decay products of radon ( $^{218}\text{Po}$ ,  $^{214}\text{Po}$  and  $^{214}\text{Bi}$ ) and thoron ( $^{212}\text{Pb}$ ) can interact with biological tissue in the lungs leading to cancer [1]. Health effects of radon, thoron and their decay products, most notably lung cancer, have been investigated for several decades. Initially, investigations focused on underground miners exposed to high concentrations of radon, thoron and their decay products in occupational environment. Recently, risk assessment for radon, thoron and their decay products both in mines

and in residential settings have provided clear insights into the health risks due to radon, thoron and their decay products [2]. Radon, thoron and their decay product are now recognized as the second most important cause of lung cancer after smoking in the general population.

Over the past two decades, sophisticated dosimetric models have been developed which enable assessment of dose to sensitive tissue in the lung resulting from inhalation of radon and thoron decay products. These models take into account the special physical properties of radon and thoron decay product aerosols which give rise to non-uniform irradiation of lung tissue by alpha particles. These include exposure concentration, exposure duration, respiratory tract anatomy, ventilator parameters, and particle properties e.g., particle size, hygroscopicity, particle shape, and density in airway fluids and cellular components. The attached and unattached radon decay products deposit in different regions of the human respiratory tract and lung, based on the aerosol size distribution [3]. The probability of deposition in the respiratory tract and lung is dependent on aerosol diameter since it influences diffusion coefficient and inertia of the particle. Therefore, the activity size distribution is one of the major parameter to estimate the dose.

The cascade impactors are widely used for measuring the size distribution of aerosol particles in environmental pollution [4] and health physics. Measurement of activity size distribution of radon and thoron decay products using several kinds of low pressure cascade impactors (e.g. Andersen, Berner, Davis, MOUDI etc) have been reported elsewhere [5-8]. The cascade impactors have more advantages due to the collection efficiency curves have steeper slope and give better cut-off characteristics. In addition, the collector plate separation has less effect on their collection efficiency and leakage is seldom a problem. On the other hand, most of the cascade impactors are expensive to assemble and require equipments that make them unsuitable for use in the field studies where no direct power supply is available.

Commercial instruments, used for the measurement of activity of alpha particle from the aerosols on impactor substrates, are expensive, too large and cumbersome to handle during field experiments. In most of studies, the activity of alpha particles is analyzed using a traditional ZnS (Ag) scintillation detector. These detectors are sensitive if exposed to light through the Aluminized Mylar window. Zinc sulfide scintillation counters are prone to window punctures. Scintillation counters can be affected by

magnetic fields, adversely affecting the instrumental response. The photomultiplier tubes are fragile, require a well regulated power supply, and degrade over time. In addition, these instruments are also mechanically affected by humidity and temperature [9]. The solid state nuclear track detectors (SSNTDS), especially allyl diglycol carbonate (commercially known as CR-39) are widely used for radon and thoron measurement to overcome above limitations [10]. In some cases, CR-39 has been used as alpha spectrometer for radon and thoron progeny monitoring. They studied the relationship between track size and energy for alpha particles. However, this technique takes much time to analyze the etched pit [11-14]. On the other hand, some researchers used the Aluminum-Mylar with various thicknesses to discriminate between radon and thoron progeny, and the results were quite encouraging [15-17].

Therefore, it is necessary to develop a portable aerosol sampler for the air sampling, and to measure the activity of attached radon and thoron progeny in field survey from the view point of dose assessment.

## **1.2 Objectives**

The main of the dissertation are:

1.2.1 To development of a device that can evaluate particle size distribution of attached radon and thoron progeny.

1.2.2 Rapid measurement of the activity concentration of attached radon and thoron progeny aerosols effectively.

## **1.3 Scope and limitation of the study**

1.3.1 Modification of a 4<sup>th</sup>-stage portable impactor sampler and CR-39 detector as an alpha spectrometer for measurement of radon and thoron progeny.

1.3.2 Test the performance of the developed technique on radon and thoron in a standard laboratory to find out alpha energy discrimination of radon and thoron progeny using aluminium-Mylar film, detector efficiency calibration, collection efficiency in the size range of 0.3-10  $\mu\text{m}$ .

1.3.3 Evaluation of parameters that affect sensitivity of the developed technique including humidity, temperature, unattached progeny and air flow-rate.

1.3.4 Validation of the developed technique with the commercial device such as MOUDI (Micro Orifice Uniform Deposit Impactor) and ELPI (Electrical Low Pressure impactor).

1.3.5 Field tests of the developed technique for dose assessment.

## **1.4 Benefits**

1.4.1 The new developed technique simultaneously measure the activity size distribution of both radon and thoron progeny in the ambient air.

1.4.2 The new technique can be used as a portable device for field studies use without AC power supply.

## **1.5 Research methodology**

1.5.1 Modification of 4<sup>th</sup>-stages portable impactor sampler using CR-39 as alpha detector to measure radon and thoron progeny

1.5.2 Experimental set up to test the performance of detector.

1.5.3 Sensitivity test of the developed technique

1.5.4 Verification of the developed technique with the commercial device.

1.5.5 To carry out the activity size distribution of the attached radon and thoron progeny measurement in ambient air for dose assessment.

## **1.6 Organization and chapter contents**

This dissertation consists of five chapters. The chapters are organized principally to focus on the assessment of dose from radon and thoron progeny exposure with an emphasis on the characteristics of activity median aerodynamic diameter determined using modification of a 4<sup>th</sup>-stage portable impactor sampler, and CR-39 as a radiation detector.

Chapter I deals with background and problem of interest, objective, scope, expected benefits and research methodology of the study.

Chapter II presents the previous work on mitigation of the effective dose of radon decay products through the use of an air cleaner in a dwelling in Okinawa, Japan.

Chapter III provides about radon and thoron decay product aerosol, the significant parameter of radioactive aerosol, measurements technique for activity size distribution, and dose assessment.

Chapter IV describes the modifications of the cascade impactor and the associated experiments to test the performance of the developed technique on radon and thoron. Parameters that might affect sensitivity and reliability of the technique have been evaluated. The findings of experiments with modified cascade impactor are also reported to obtain the most desirable results.

Chapter V describes the experimental result of attached radon and thoron progeny size distribution using developed technique which was obtained at Thailand smelting and refining Co. Ltd. The experimental results support for dose calculation using the particle size those play a significant role.

Finally in Chapter VI, the overall findings of the studies are summarized and discussed.