A GIAN Course On

♦ Applications of Nuclear Techniques in the Investigation of Monsoon Dynamics and Atmospheric Pollutants

May 14-24, 2019

Center for Advanced Research in Environmental Radioactivity (CARER), Mangalore University, Mangalagangotri-574199, India

Brochure link: www.mangaloreuniversity.ac.in/carer

Overview

Radon (^{222}Rn, ^{220}Rn and ^{219}Rn) and its relatively long-lived daughter products (e.g. ^{210}Pb, ^{210}Bi and ^{210}Po) that originate from the ^{238}U-^{235}U-^{232}Th decay chains have been widely utilized as tracers and chronometers in our understanding of the earth and near-earth surface processes. Of the 33 Pb isotopes ($^{182\text{-}214}$Pb) that occur in nature and produced inside the laboratory, only 4 are stable (^{204}Pb, ^{206}Pb, ^{207}Pb and ^{208}Pb). Of these 29 radioactive Pb isotopes, four radioactive isotopes are produced from the ^{238}U (^{214}Pb, $T_{1/2}$=26.8 min.; ^{210}Pb, $T_{1/2}$=22.3 yr), ^{235}U (^{211}Pb, $T_{1/2}$=36.1 min.) and ^{232}Th series (^{212}Pb, $T_{1/2}$=10.64 hr.) (Porcelli and Baskaran, 2011). Due to low abundance and relatively short half-life, ^{211}Pb is of less importance as a tracer. There are 27 Po isotopes ($^{192\text{-}218}$Po) all of which are radioactive that occur in nature or produced inside the laboratory of which the longest-lived radionuclide that occur in nature is ^{210}Po ($T_{1/2}$=138.38 d). Six of these 27 radioactive isotopes are produced from the ^{238}U (^{218}Po, $T_{1/2}$=3.10 min.; ^{214}Po, $T_{1/2}$=164 μs; ^{210}Po, $T_{1/2}$=138.38 d), ^{235}U (^{215}Po, $T_{1/2}$=1.78 ms) and ^{232}Th series (^{216}Po, $T_{1/2}$=0.145 s; ^{212}Po, $T_{1/2}$=0.299 μs).

When chemically inert radon gas is produced in the upper earth's crust from the decay of U-Th series, a fraction of it diffuse out of the crust and is transported by turbulence and advection through the atmosphere. When these isotopes undergo radioactive decay, heavy metal atoms are produced which rapidly become attached to natural aerosols, including ^{212}Pb, ^{214}Pb and ^{210}Pb which eventually return to surface earth through atmospheric scavenging processes. The journey of radon and its daughter products including ^{210}Po and ^{210}Pb through the atmosphere, hydrosphere and biosphere has been a major area of research over the past 40-50 years. The activities of ^{222}Rn and its progeny ^{210}Po, ^{210}Bi, ^{210}Po along with activity ratios

of $^{210}Pb/^{222}Rn$, $^{210}Po/^{210}Pb$ and $^{210}Bi/^{210}Pb$ are quite useful as tracers in the study of atmospheric dynamics and sources and removal rate constants of these nuclides.

The proposed course is relevant to meteorologists who investigate surface- and upper-air mixing as well as identification and quantification of continental and maritime air masses. In addition, it is directly relevant to those who investigate depositional fluxes of heavy metals, organic pollutants, residence time and removal rate constants of aerosols, and sources of aerosols. This course will present lectures to those active researchers in Meteorology and Atmospheric science who work with aerosols, changes in the frequency and amounts of precipitation, cloud formation processes, and atmospheric fallout and pollutant studies.

The scope of the 2-weeks, 2-credit advanced course is to teach the applications of nuclear techniques using alpha, beta, gamma and scintillation counting and mass spectrometry methods for the study of monsoon dynamics and sources and fate of atmospheric pollutants. At the end of this course, the participants are expected to know all the intricate details of utilizing a suite of naturally-occurring isotopes and advanced nuclear spectroscopy techniques for the measurements of these isotopes. The participants will be asked to calculate the vertical and horizontal mixing of air masses during monsoon season, calculate the residence times of aerosols, flux calculations and identify the sources and sinks of atmospheric pollutants. The participants will also undergo a rigorous training through well planned laboratory experiments and field visits and analysis of field samples (precipitation, aerosols, etc.).

Dates	*May 13-25, 2019* *Number of participants for the course will be limited to 50*
Who can attend	Ph. D students, Post Graduate Students, faculty from Universities and research institutions, scientists from R&D laboratories such as, BARC, IGCAR, GSI, NIO, PRL, etc., and technical staff from industries.
Fees	The participation fee (including taxes) for taking the course for different categories is as follows: **Industry : Rs. 20,000** **Scientists/ Faculty : Rs. 12,000** **Research Scholars : Rs. 8,000** **Students : Rs. 4,000** The above fee includes all instructional materials, computer usage, internet facility, lunch and tea during session breaks. Participants will be provided accommodation on payment basis subject to availability.

The Faculty

Dr. Mark M Baskaran is a tenured Full-Time Professor and Chair in the Department of Geology at Wayne State University (Detroit, Michigan). He received his Ph.D. in Physics from Physical Research Laboratory (PRL). He has published over 145 peer-reviewed articles (with over 6900 Google Scholar cumulative citations, h-index 50), most of which are related to the applications of isotopes as tracers and chronometers in Earth systems.

He edited a two-volume Handbook entitled "Handbook of Environmental Isotope Geochemistry" with forty articles contributed by eminent scholars in the field in 2011, published by Springer. He also published a monograph on radon entitled

"Radon: A Tracer for Geological, Geophysical and Geochemical Studies"--Springer 2016. He serves as an Associate Editor for two Elsevier journals, *Journal of Environmental Radioactivity* and *Estuarine, Coastal, and Shelf Science*.

His Research Interest/Area of Expertise

- Applications of short-lived radionuclides as tracers and chronometer;
- Dating of sediments, carbonates (corals, speleothem, mollusk shells, etc);
- Investigations on the distribution of ^{210}Po and ^{210}Pb for particle cycling, particle export, and remineralization in marine environment;
- Investigations of sea ice, ice-rafted sediments and snow from the Arctic for the age of ice-rafted sediments, ice core dating and accumulation-ablation rates of sea ice;
- Radium, radon as submarine groundwater exchange tracers in freshwater systems, and
- Isotope Geochemistry

Dr. Karunakara Naregundi, Professor & Coordinator at the CARER, Mangalore University. He has so far published 78 papers in national and international journals. He has 25 years of experience in wide ranging topics in the fields of radioecology and radiation protection, development of

new measurement techniques and instruments for the Radon and Thoron measurements and mitigation. He is a recipient of Sir C V Raman Young Scientist Award from Govt. of Karnataka and Dr. A K Ganguly Award by the Indian Association for Radiation Protection (IARP)

Detailed Course Outline

DAY 1

Session/faculty/ duration	Title of lecture	Brief contents lectures &expected skills to be developed from laboratory session
Lecture Session 1 MMB 2hrs 10:00 – 12:30 hrs (30 min break)	Basics of natural radionuclides in the environment and nuclear detection techniques	Radionuclides and select stable isotopes in the environment – sources, properties, behavior, transport. Decay chains of ^{238}U, ^{235}U, ^{232}Th and in particular the progeny of ^{222}Rn. Detection techniques – GM counter, proportional counters, alpha, beta and gamma spectrometry, mass spectrometry.
Laboratory session 1/Tutorial NK+MMB 2hrs 14:30 – 16:30 hrs	Introduction to basic nuclear counting system	Understanding the principles of operations of GM Counter, proportional counter, gas flow beta counting, ZnS(Ag) detectors, etc. Hands on experience in gross counting techniques – limitations of these systems.

DAY 2

Session/faculty/ duration	Title of lecture	Brief contents lectures &expected skills to be developed from laboratory session
Lecture Session 2 MMB 2hrs 10:00 – 12:30 hrs (30 min break)	Tools of the Trade – Applications of alpha, beta and gamma spectrometry	Need for obtaining high quality data using alpha, beta, gamma-ray spectrometers and scintillation counter. Need to apply self-absorption and external absorption corrections in gamma-ray spectrometry. Need to apply summation correction in gamma-ray spectrometry. Algorithm development and case studies.
Laboratory session 2/Tutorial NK+MMB 2hrs 14:30 – 16:30 hrs	High Pure Germanium (HPGe) detector	Concept, calibration, use of software. Identification of unknown radionuclide. Determination of activity in a sample.

DAY 3

Session/faculty/ duration	Title of lecture	Brief contents lectures &expected skills to be developed from laboratory session
Lecture Session 3 MMB 2hrs	Physical, chemical & nuclear properties of radon and radon emanation rates	Methodology for radon measurements – Integration radon monitors; continuous monitors; analysis of radon using its progeny Radon measurements of surface air.

10:00 – 12:30 hrs (30 min break)		
Laboratory session 3/Tutorial NK+MMB 2 hrs 14:30 – 16:30 hrs	Alpha spectrometry	Semiconductor detectors - Calibration, Internal tracer, determination of activity concentration. Analysis of polonium in environmental samples.

DAY 4

Session/faculty/ duration	**Title of lecture**	**Brief contents lectures &expected skills to be developed from laboratory session**
Lecture Session 4 MMB 2hrs 10:00 – 12:30 hrs (30 min break)	Mechanisms of radon emanation and long-term radon flux studies	Factors that affect radon emanation rates; radon ocean flux studies; radon flux studies from continents; radon activity variations in the PBL above land and ocean.
Laboratory session 4/Tutorial NK+MMB 2hrs 14:30 – 16:30 hrs	Self- and external absorption corrections	Demonstration of lack of coherency between alpha spectrometry data and gamma-ray spectrometry data; show evidence to students how the self- and external absorption can affect the quality of data.

DAY 5

Session/faculty/ duration	**Title of lecture**	**Brief contents lectures &expected skills to be developed from laboratory session**
Lecture Session 5 MMB 2hrs 10:00 – 12:30 hrs (30 min break)	Application of radon in atmospheric studies	Role of Atmospheric Rivers in the transport of radon and radon storms; Application of radon as Indian monsoon air circulation tracer; application of radon as a proxy for other pollutants.
Laboratory session 5/Tutorial NK+MMB 2hrs 14:30 – 16:30 hrs	Collection of aerosols and analysis	Aerosol sampling and handling of large volume aerosol collectors; learn how to quickly digest aerosol filters and conduct quick analysis.

DAY 6

Session/faculty/ duration	**Title of lecture**	**Brief contents lectures &expected skills to be developed from laboratory session**
Lecture Session 6 MMB	Applications of radon progeny in atmospheric studies	Sources, fluxes and distribution of radon and its progeny; Depositional fluxes of ^{210}Pb and ^{210}Po; vertical profiles of ^{210}Po, ^{210}Pb and ^{222}Rn; ^{222}Rn

2hrs 10:00 – 12:30 hrs (30 min break)		global flux curve; ^{210}Pb as global air mass tracer.
Laboratory session 6/Tutorial NK+MMB 2 hrs 14:30 – 16:30 hrs	Field visit – 1	Cascade impactor sampler: Anderson sampling - Demonstration of the Anderson sampler for aerosols size separation and analyses.

DAY 7

Session/faculty/ duration	**Title of lecture**	**Brief contents lectures &expected skills to be developed from laboratory session**
Lecture Session 7 MMB 2hrs 10:00 – 12:30 hrs (30 min break)	Applications of ^{210}Po and ^{210}Pb in the atmosphere	Determination of residence times of aerosols (in size-fractionated aerosols) from the disequilibrium between ^{210}Po and ^{210}Pb. Estimation of washout ratio and deposition velocity of aerosols. Relative importance of dry fallout versus wet fallout; global fallout curve.
Laboratory session 7/Tutorial NK+MMB 2hrs 14:30 – 16:30 hrs	Field visit – 2	Deposition rate measurements: Measurements of deposition velocity, deposition density.

DAY 8

Session/faculty/ duration	**Title of lecture**	**Brief contents lectures &expected skills to be developed from laboratory session**
Lecture Session 8 MMB 2hrs 10:00 – 12:30 hrs (30 min break)	Other applications of short-lived radionuclides	Radon progeny as a tracer of atmospheric mercury. ^{210}Pb as an atmospheric tracer for the sources, fate and transport of stable Pb. ^{204}Pb, ^{206}Pb, ^{207}Pb and ^{208}Pb as tracers of atmospheric Pb.
Laboratory session 8/Tutorial NK+MMB 2 hrs 14:30 – 16:30 hrs	Field visit –3	Aerosol sampling using high volume samplers and gamma spectrometric evaluation.

DAY 9

Session/faculty/ duration	Title of lecture	Brief contents lectures &expected skills to be developed from laboratory session
Lecture Session 9 MMB 2hrs 10:00 – 12:30 hrs (30 min break)	Case Study – 1.	Residence time of aerosols in New Delhi, Ahmadabad, Mount Abu using ^{210}Po/ ^{210}Pb/ ^{210}Bi activity ratios.
	Case Study – 2.	Monsoon studies using ^{222}Rn in the Arabian Sea and Bay of Bengal.
Laboratory session 9/Tutorial NK+MMB 2hrs 14:30 – 16:30 hrs	Application of liquid scintillation spectrometry in the determination of radon and its progeny concentrations.	

DAY 10

Session/faculty/ duration	Title of lecture	Brief contents lectures &expected skills to be developed from laboratory session
Lecture Session 10 MMB 2hrs 10:00 – 12:30 hrs (30 min break)	Case Study – 3.	Estimation of dry and wet deposition rates for fallout radionuclides, scavenging ratio, mixing rate.
	Case Study – 4.	Determination of air-sea exchange rates using ^{222}Rn as a tracer.
Laboratory session 10/Tutorial NK+MMB 2hrs 14:30 – 16:30 hrs	Calculations, revisions, problems etc.	

Course Faculty: **MMB : Mark M Baskaran** **NK : Karunakara N**

All communications including the completed registration form (please see next page) may kindly be mailed to:

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