

Radon Studies for Uranium Exploration, Environment Health Hazards and Earthquake Prediction

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During 1975, when my research laboratory in Geochronology became operational in Punjabi University, Patiala, I came in contact with Robert McCorkell, a geologist of Carleton University in Ottawa, Canada. He helped me a lot in sending literature concerning my research in inter-disciplinary areas of my choice. He suggested that using simple instrumentation, one can start some research activity in Radon monitoring in soil and groundwater. On the basis of his suggestion, I applied for a project and CSIR sanctioned "*Radon and Thoron Estimation in Soil and Water*" in 1979 for three years, at a first instance. In those days, I never thought that Radon monitoring and investigations of its health hazards will keep me busy for next twenty years. However, we had a multi-prong approach to our Radon studies and found applications in biogeochemical exploration of Uranium, earthquake prediction research, and geothermal springs.

On 10th July, I joined Guru Nanak Dev University (GNDU), Amritsar, Punjab, India to start a new Department of Physics. I shifted my research activities in Geochronology from Punjabi University, Patiala to Guru Nanak Dev University, Amritsar. Despite of being overburdened by administrative responsibilities, my commitment to promote research in newly created department was not diminished. Within a short span of six months, two research scholars, P.S. Suri, a research scholar from Chandigarh, and SK Modgil, a school teacher from Kapurthala, joined my team. Suri started working under CSIR sanctioned Radon-Thoron project and Modgil on 'Calibration of Glass Dosimeters', as part of his M.Phil. Thesis. My first paper "*Intercalibration of Glass Dosimeters for Neutron Fluence Determination*" was published in "International Journal of Applied Radiation and Isotopes" in

1980. P.S. Suri was a geologist by training and proved to be a great asset in collection of samples from Siwalik Himalayas for our Radon project. Our first paper "*Uranium and radon estimation by plastic track detectors*" was published in "Indian Journal Pure and Applied Physics" in 1981.

Our first priority was to set up B.Sc. and M.Sc. laboratories for students and most of our UGC (University Grants Commission) grants were used up for this purpose. However, we were able to import some glass dosimeters and tektite samples from our project grants. It was an arduous task to get the sanctions for purchase of items from abroad as it involved foreign exchange, which required the approval of 'Reserve Bank of India'. There was always the risk of lapsing of sanctioned grant due to bureaucratic hurdles of university and other agencies. Many researchers felt discouraged to undertake research projects simply because of these hurdles. But I had adopted myself to the environment at the risk of losing my patience.

When our Radon project was at a take off stage, Mr. Suri left to join his parental department in Punjab University, Chandigarh, India. I was left with no choice but to advertise the vacancy and fill it with a fresh recruit. NP Singh joined us after passing out M.Sc. Applied Physics from Punjabi University, Patiala in 1982. Manvinder Singh, M.Sc. in Chemistry from GNDU, was also selected on a University fellowship to join my team. He was a great help in starting our investigations using Radon in earthquake prediction studies. Our work involved chemical etching of samples and as a Chemist, he was another great asset. Our paper "*Calibration of Radon Detectors*" published in Nuclear Tracks and Radiation Measurements in 1986 is a tribute to his ingenuity and it has been one of the foremost

papers on calibration studies in India to be cited by other workers. Tehal Singh joined our team but after one year, he left to join some other department. His paper "A New Track Etchant for Plastic Detectors" was published in Nuclear Tracks in 1982. We had to discard this useful investigation into new etchants after he left. I recount this story to impress upon new investigators that stability of research group is a necessary condition for producing quality work. By 1983, our research group attained some semblance of stability and we could move forward to achieve our targets.

Radon-Thoron studies were going on along with fission track dating and radiation damage annealing studies by my group. Our main problem was Radon-Thoron detectors which could record Alpha particles with 100% efficiency. Most of the laboratories in India were using LR-115 Type-2 plastic detector for Radon monitoring. We adopted a multi-prong approach by monitoring Radon in soil, water, plants, indoor air and outdoor air. Our experiment started on GNDU campus in the vicinity of Physics Department, where we made boreholes to suspend Radon-Thoron discriminator to record Alpha particles on plastic detector sheets. To study the background effect, we monitored Radon in the environment of our recording station. Uranium estimation of the soil at the Radon station site was also determined to find correlation between Radon emission and Uranium. Our first two papers, "*Radon-Thoron Estimation using LR-115 Plastic Track Detector*", and "*Uranium and Radon Estimation in Water and Plants using SSNTD*" were published in Nuclear Tracks and Radiation Measurements in 1984.

Our Radon studies were directed for earthquake prediction research during 1984 when we observed some anomalies in radon emission in the soil of the GNDU campus. The data was reported at an International Conference held in Pune University, and published in its proceedings in 1986 under the title "*Radon Monitoring and Earthquake Prediction*". During 1987, Department of Science and Technology (DST), Government of India invited proposals under the Earth Sciences Division for major research projects.

I considered it as an opportunity to execute our plans for promoting Radon studies in the area of Earthquake prediction research. DST meeting was held in Presidency College, Kolkata where I made my presentation before a high powered committee of earth scientists with Prof. V.K. Gaur in the chair. Most of the investigators submitted proposals to the tune of ten million Indian Rupees. I was asked to revise my proposal and resubmit with enhanced budget for equipment. It took almost three years when the DST project was sanctioned in 1990 with a budgetary provision of one million rupees, which was beyond my expectations.

Under this project, we imported one dozen Alpha Logger probes from Alpha- NUCLEAR Company of Canada. We had already purchased Alpha-GUARD Radon Monitor (Genitron Instruments GmbH) and Alpha Scintillometer (GBH Electronic) from Germany for soil and water measurements for the field survey. Similarly, we were equipped with Radon-Thoron Discriminator device supplied by BARC, Department of Atomic Energy (DAE), India. Perhaps, we had the best facilities to undertake Radon-Thoron studies and their health hazards to population in Punjab and Himachal Pradesh (HP); as well as applications to earthquake prediction research in these areas. During the decade of 1990-2000, our research group was running three projects simultaneously: Radon- Thoron studies in soil and water; Radon-Thoron Health Hazard Survey Indoors in Punjab; and, Radon monitoring for earthquake prediction in Punjab and Himachal Pradesh. Our team members in these projects were Rajinder Singh, Baljinder Singh, Rakesh Chand Ramola, Anand Kumar Sharma and Vivek Walia. Radon Survey for Biogeochemical Exploration of Uranium was almost complete in which M. Singh, N.P. Singh and R.K. Ramola participated. In fact, these three members were founding fathers of our Radon network. We undertook Radon monitoring surveys in Punjab and Himachal Himalayas for many years. Our main station was located on the Campus of HPKV (Himachal Pradesh Krishi Vishvavidyalaya), Palampur, Himachal Pradesh. At one time, we were running ten Radon monitoring stations in Punjab and

Himachal Pradesh. I was also a participant occasionally in Radon survey teams during the field work.

There was an unexpected windfall in 1996. The Punjab Government called a meeting of Disaster Management Committee in Chandigarh, Chaired by Dr. Manmohan Singh IAS under the aegis of Revenue Department. I knew Manmohan Singh since 1965 when he was teaching in Chemistry department of Punjabi University, Patiala. The committee was informed that a grant of Rs. 5 million was available in Revenue department for mitigation and management of disasters in the Punjab state sanctioned by the Govt. of India. Since there were no floods or any other disaster occurrence in Punjab during the past three years, this grant may lapse in next two years if not spent for the purpose for which it was sanctioned. I was asked to submit a project proposal which I did under the title, "*Seismo-Tectonics and Earthquake Studies in the State of Punjab*", and a grant of Rs. 2.5 million (25 lakhs) was sanctioned after two expert Seismologists recommended it strongly. We imported equipment for setting up three Seismic stations equipped with state of the art Seismographs.

We collected seismic data for three years at Amritsar, Hoshiarpur and Thein Dam, near Pathankot. Micro-seismicity was recorded in Punjab and Siwalik Himalayas. Our Radon stations were already functioning in these areas. Hence, it proved beneficial and convenient to record Radon anomalies and find their correlation with seismic activity in the region. During this period, there occurred an earthquake of magnitude 5.7 in the Himachal Pradesh which was strongly felt in Chandigarh, India. The next day, I was called by the Revenue Commissioner of Punjab (Shyama Mann) to explain why this event was not reported in advance by our monitoring stations? I told her that the seismic signal was recorded at all the stations but prediction of earthquakes has not yet become possible anywhere in the world. The commissioner lost her temper in the meeting and ordered to wind up this project if prediction is not possible. I felt deeply insulted and left in a huff after giving her a bit of my mind. I am telling this

episode to show how ill-informed our bureaucracy is towards the needs of Science and Technology in Punjab, India.

The data recorded by our Seismic stations was so good that our paper "*Estimation of Coda Waves Attenuation for NW Himalayan Region using Local Earthquakes*" has recorded maximum number of citations till date in comparison with 400 other research papers published by my group. The only thing which had been bothering us after winding up of the project was that our seismic data recorded on floppy disks will be corrupted and rendered useless for future studies as a bench mark. We failed to transfer seismic data on compact disc (CD) and lost it. Sanjay Sood and his fiancée, Parwinder Kaur, were both engaged in this project to record data on the spot. Telemetry or online facility for transfer of data to our central station in GNDU Amritsar was not available.

We can boast of recording seismic events generated by the nuclear explosions after the underground testing of Atom Bombs by both India and Pakistan during May 1998. It is unfortunate that after the closure of project by Punjab Government in 2001, the University failed to provide even maintenance grant for running it. Equipment worth millions of rupees is rusting without proper maintenance. I enjoyed the status of Director Earthquake Research Centre for five years though my privileges and financial powers were curtailed by authorities of GND University without any rhyme or reason. My experience of running this project ended up in frustration!

During a span of 21 years (1984–2005), our group published 100 research papers under all these projects. The readers may download all these papers from Research gate: www.researchgate.net/profile/Hardev_Virk/publications. The list of papers is available at the end of the paper. Most of our Radon research work was presented at International Conferences. Out of my ten highly cited papers on Google Scholar, eight pertain to Radon studies for earthquake prediction. The topmost paper with one hundred citations is "*Radon recording of Uttarkashi Earthquake*" published in Geophysics Research Letters (1994). That confirms the popularity of our

Radon studies for earthquake prediction research. It needs to be reported that our Radon studies may be used as bench mark for further investigations in the area of earthquake prediction research in India; though we failed to achieve our target of prediction but found reliable windows for prediction.

To augment our research facilities, DST sanctioned us portable Helium Mass Spectrometer Leak Detector (Alcatel ASM 10) for measurements of Helium concentration emission in soil and water. We imported two sets of equipment for this purpose; one was installed in Palampur and the other in Manikaran (both in Himanchal Pradesh).

However, due to logistic problems, we could not make use of this sophisticated equipment efficiently. Our Radon data was compatible with Helium data in two events recorded in HP. Another useful application of this equipment was made to monitor Radioactivity of Thermal Springs and tectonic features in the Himalayas as reported in our papers: "*Radon/Helium Monitoring in Some Thermal Springs of North India and Bhutan*" published in *Current Science* (2002), and "*Radon, Helium and Uranium Survey in Some Thermal Springs located in N-W Himalayas, India: Mobilization by Tectonic Features or by Geochemical Barriers?*" published in *Journal of Environmental Monitoring* (2005).



Fig. 1: Radon Recording in Soil in Ropar District (Punjab) using Alpha Guard in the field (with Rajinder Singh).



Fig. 2: Radon Recording in Chamba Area (H.P.) using Alpha Probe (with Vivek Walia).



Fig. 3: Radon Recording in Groundwater of Natural Spring (Boali) in HPKV, Palampur (Himanchal Pradesh) (with Rakesh Ramola and Baljinder Singh).

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List of our Publications Pertaining to Radon Studies

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