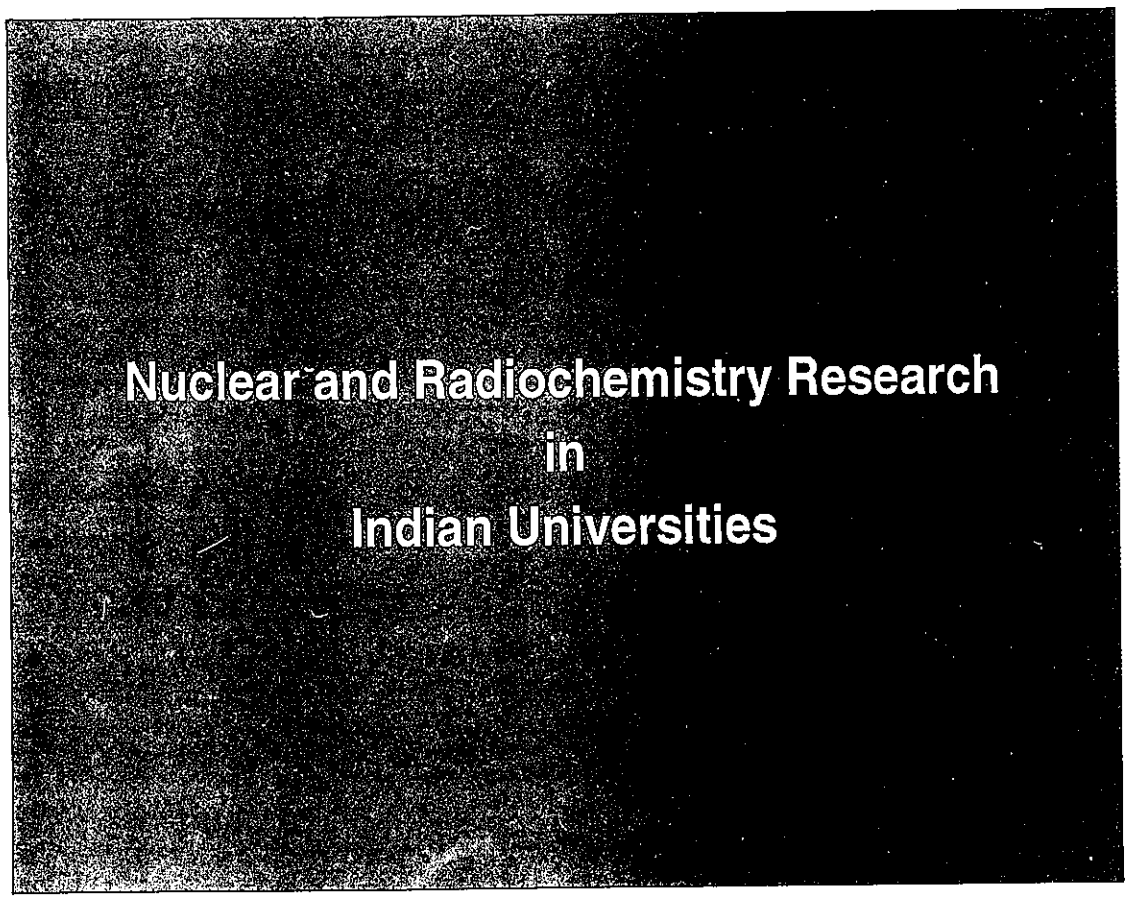
INDIAN ASSOCIATION OF NUCLEAR CHEMISTS
AND ALLIED SCIENTISTS



IANCAS Bulletin

March 2000 • Vol. 16 • No. 1

Vol. 16. No. 1 Editor : Dr. M.R.A. Pillai March 2000

Editorial

The research in nuclear sciences which has its origin in the late nineteenth and early twentieth century in poorly equipped University laboratories moved quickly to well funded and well equipped national laboratories. This transformation was mainly due to the immense potential of nuclear sciences in defense related applications. Associated with this development was the high degree of confidentiality attached to the research activities in nuclear chemistry and radiochemistry. Post World War II, a number of radioisotopes as tracers and radiation sources were developed and exploited for a wide variety of applications. Thanks to these peaceful applications in medicine, industry, agriculture etc. a number of Universities in North America and Europe started taking renewed interests in nuclear sciences. Due to the pioneering research done in several Universities a number of products and processes were developed, patented and brought to actual use.

The Bhabha Atomic Research Centre has been the focus point for research in nuclear chemistry, radiochemistry and isotope applications. In addition, a few University departments have also been carrying out good quality research in radiochemistry, activation analysis and isotope applications. IANCAS has been striving hard to induce more Universities into this fascinating field of science. Hence, it was felt appropriate at this stage to bring out a special issue on "Nuclear and radiochemistry research carried out in the Indian Universities". This issue is guest edited by Dr. K.L. Ramakumar, Fuel Chemistry Division, BARC who has taken enormous efforts to solicit articles from a large number of University teachers of which four have responded positively. Dr. Ramakumar has done an exemplary job in editing the articles and I am thankful to him and the authors who contributed to this issue.

This is the eighth and the last Bulletin from the present Executive Committee and I take this opportunity to thank all the guest editors, contributors and readers of IANCAS Bulletin.

M.R.A. Pillai

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Nuclear Chemistry Laboratory and Nuclear Chemistrty Division of the Institute of Science, Mumbai

Dr. Z.R.Turel did her M.Sc. in Inorganic Chemistry at the University of Gujarat. She did her Ph.D. under the guidance of Dr. B.C.Haldar, the Ex-Director of the Institute of Science, Mumbai in Nuclear and Radiochemistry. She is one of the pioneers of nuclear activation analysis in India. She is a research guide for M.Sc. and Ph.D. students of the Mumbai University. She is in-charge of the new Nuclear Chemistry Laboratory of the Institute of Science, Mumbai. Dr. Turel is the only lady to have obtained D.Sc. of the Mumbai University and was awarded the Best Professor of the university and Maharashtra State and also All India Institute of Medical Sciences Silver Jubilee Oration Award (non-clinical), Bharat Nirman Award for the Best Lady Scientist. She was felicitated by Sheriff of Mumbai for her scientific contributions. Prof. Turel has been a visiting Professor at University of Maryland, USA and an expert for IAEA. She was also awarded an honorary M.D. Degree at a special convocation in Denmark. She has travelled abroad for delivering invited and plenary lectures at international conferences and visited nuclear installations. Dr.Turel was the Chairperson of the 3rd International Conference on Low level measurement of actinides and long-lived radionuclides in biological and environmental samples held in 1990. She holds the K.C.Mahindra Chair of nuclear chemistry and is the Head of the Division. She was elected twice as the Vice-President, IANCAS.

Introduction

The applications of radioisotopes in diverse fields such as high purity materials, industry, medicine, geology, environment, agriculture etc. constitute the most widespread use of the atom. Radioisotopes are being increasingly used in all sectors of education and they have contributed significantly to the improvement of public health, agricultural practices and industrial processes. With an objective of catering to research and development work at University level in nuclear and radiochemistry, a Department for research and teaching in the nuclear and radiochemistry was founded at the Institute of Science, Mumbai.

The Department was created by Dr. B.C. Haldar, who was one of the Post-Doctoral students of Nobel Laureate Prof. Glen T. Seaborg. Dr. Haldar strove to establish nuclear and radiochemistry at the institute and at the university on a firm footing. The nuclear chemistry laboratory was started functioning in 1962 and a separate department was established in 1975. A full fledged laboratory, later christened as nuclear chemistry division, was constructed, equipped and commissioned in consultation with the scientists of the Bhabha Atomic Research Centre, Dr. Haldar and Dr.(Mrs.) Turel. It was commissioned on August 13, 1984. The laboratory has all the facilities required of a good nuclear and radiochemistry laboratory. It has now grown into an important centre of research and teaching of nuclear and radiochemistry in India and is the focal point of many collaborative programmes between central and state governments.

Dr. Trivedi was the first associate professor, Dr. Z.R.Turel is the K.C.Mahindra Chair Professor and Head of the Department. Shri T.A.Subramnian is the lecturer in Radiation Chemistry.

Facilities at the Nuclear Chemistry Laboratory

The nuclear chemistry laboratory houses the facilities such as ^{252}Cf coupled to a pneumatic transfer system. Source is a 750 μg of ^{252}Cf having 3 neutron irradiation positions. Paraffin is used as moderator and cement, concrete and Pb as biological shields. The thermal neutron flux output is of the order of 8.7×10^7 n/cm^2/sec.

The second neutron source ^{241}Am-Be employs paraffin moderator and concrete for biological shielding. The thermal neutron flux output is $4x10^5$ n/cm^2/sec. Both these sources are located in the basement.

The ground floor contains change room (which doubles as decontamination room), instrument analysis room, counting rooms, two B-type (medium level radioactivity), two C-type labs (low-level radioactivity), isotope storage room etc. The storage room contains various isotopes (milli Curie levels) used for tracer studies and neutron irradiated sample prior to processing. The isotopes are adequately shielded by Pb bricks.

The first floor contains air exhaust pump. The pump is connected to a chimney, which is 10 ft above the surrounding buildings. One laboratory for chemical work, computer room, instrument room, staff rooms and 2 lecture rooms constitute the first floor.

Each of the four active laboratories is equipped with two stainless steel fume-hoods connected to filters. The fifth laboratory is equipped with three glove boxes for handling alpha activity.

The laboratory also houses facilities such as radiochemical hoods, glove boxes, HPGe detector coupled to PC based MCA, proportional counter, gamma ray spectrometer, GM counters, liquid scintillation counter, Survey meter, β-γ monitor, contamination monitor, Pb bricks, Pb glass, remote control tongs and all the usual facilities of a normal chemical laboratory.

The background of the laboratory is monitored by contamination monitor and personal monitoring is achieved by hand-cloth β-γ monitor.

Field of Specialisation

Prof. B.C.Haldar and Prof.(Mrs.)Turel have extensively worked in the field of neutron activation analysis (NAA) and its different manifestations such as radiochemical neutron activation analysis (RNAA), instrumental neutron activation analysis (INAA) for solving problems related to the determination of elements in medicine, agriculture, geology, environmental pollution, dietetics, ultrapure materials, ayurvedic medicine etc. Besides, they have also contributed substantially to the development of rapid and selective radiochemical separation procedures employing solvent extraction, precipitation and ion exchange. Given below in brief are some of the research contributions from the Institute of Science, Mumbai.

Agriculture

The US agriculture department experts reported that the Mexican variety of wheat was not growing well in Gujarat. So was the case with *santra* (orange) in Nagpur. It was suggested that it might be due to excess or deficiency of macro or micronutrients in the soil. Analysis of the leaves by RNAA indicated that the soil was well fortified with micronutrients but macronutrients such as K and P required attention. RNAA has also been used for the determination of mineral nutrients such as Cu, Mn, K, P, Mo, Ca, and Fe in Nagpur santra leaves when, during a particular season the yield was poor. The results helped in characterising the mineral deficiency in soil so that corrective measures could be taken to increase the yield of santra in the following season.

Root Distribution Studies

It is the practice to add fertilisers in a random way. Knowledge of the relative intensity of activity of roots of plants is of great importance in optimising the utilisation of nutrients. A study was therefore undertaken to determine the area of maximum root activity so that fertilisers can be added at a specific area to optimise the utilisation and to prevent wastage. The distribution of root activity of coconut palm was studied by applying Rb salt, around the palm at different distances and depths and then estimating the amount of Rb recovered in the palm leaves. Untreated samples were considered as control and Rb in the coconut palm leaves was determined by neutron activation analysis (NAA).

Micronutrient Status of Soil

With a view to determining the status of soil and preparing its contour map with respect to the availability of micronutrients, soil from various districts and interior places in Maharashtra state were analysed for their micronutrients such as V, Al, Na, K, Fe, Co, Cu, Zn, Fe, B, Mo, Mn etc. (both total and available). A data bank was thus made available for

future reference to the farmers. INAA, RNAA, and AAS techniques were employed in the study.

Medicine

Plants of Medicinal Importance

Seeds of the indigenous plant *Psoralea Corylifolia linn*, commonly known in vernacular as Bawarchi have been reported to be useful against leucoderma and other skin diseases in the Indian system of medicine. The seeds, when analysed by NAA after their extraction in different solvents showed that they contained not only Cu but also Se, As and Sb at microgram levels. The curative effect of these metals at trace levels is well known in the Ayurvedic system of medicine. Similarly, the seeds of the plant *Semicarpus anacardaceae* and *Vinca rosea*, which showed anticancer properties and caused regression of the tumour were also analysed and their curative action studied.

Metals as Carcinogens

The recent worldwide interest in the role of elements in pathological metabolic process, multielemental determination assumes great importance. Investigation was undertaken to analyse the concentration of elements in normal, malignant, and non-malignant tumour tissues (breast, brain, and bones) for the purpose of ascertaining the significant differences in elemental concentration with respect to the affected and normal tissues and to use this data for developing a diagnostic tool if possible, The tissue samples were collected from Tata Memorial, Masina, Bhatia, J.J. and Parsi General hospitals. The tissues of more than 100 patients have been analysed both by RNAA and INAA using ^{252}Cf and reactor neutrons to arrive at some definitive conclusions.

Dietetics

Macro and micronutrients were analysed by NAA to determine the concentration of these elements in the nasogastric feeding given to patients suffering from throat cancer. The feed sample was collected from Tata Memorial Hospital and it was observed that some of the micronutrients like Co required augmentation whereas the diet was well fortified with macronutrients and other micronutrients.

Geology

A systematic search for economically and industrially exploitable ores and rocks containing Re and Pt metals in the country and Maharashtra was carried out by RNAA and INAA. The results of the analysis revealed that the Cu ore from Jaduguda mines was rich in Re. A pilot process was developed for obtaining Specpure Re from the ores. A pilot plant procedure has also been developed for the extraction and separation of Pt metals from its ores.

Pollution of Aquatic Environment by Heavy Metals

An investigation on the pollution of aquatic environment with respect to heavy metals such as Pb, As, Se, Cd and Cu in and around Mumbai by RNAA was undertaken. The different locations investigated were Kalu river, Thane creek, other creeks around Mumbai, Mulla and Mutha rivers, drinking water, vegetables grown with sewage water along the Western Railway tracks etc. The extent of pollution in aquatic environment with respect to Cd, Hg, Cu, As, Se, Cr, Zn etc. was ascertained and some of the data was made available to the authorities concerned for necessary action. Parameters affecting the uptake of the heavy metals were also studied.

Standard environmental samples such as oyster homogenate, orchard leaves, water etc., supplied by IAEA, Vienna were analysed employing INAA.

Radioanalytical Chemistry

Separation Methodologies

Solvent extraction, inorganic ion exchangers and precipitation techniques are used for the separation of elements from complex matrices and from each other. These techniques are very important in radioanalytical chemistry because they are rapid, selective and lend themselves to radiochemical separations.

Separation of elements such as Pd(II), Ir(IV), Zn(II), Cd(II), Hg)II), Sb(III), Eu(III), An(III), Ag(I), Cu(II), La(III), Mo(VI), W(VI), Tc(VII), Re(VII), Mn(II), Fe(II), Co(II), Pt(IV), Cs(I), Sc(III), Br(I), Ru(III), Tl(VI), In(III), Sr(II), Zr(IV), Ce(III), Cr(III), Cr(VI), Os(IV), Fe(III), Ni(II), Na(I), K(I), S(VI), P(V), Rb(I) etc. from each other and also from other elements as well as from neutron irradiated

targets. These methods have been employed where the trace elements have to be determined in a variety of complex matrices by RNAA. Tracers were employed for developing the separation procedures.

Substoichiometry Methods

Substoichiometry in radiochemical separations has the advantage of elimination of chemical yield determination thus reducing the time of separation and improvement of the selectivity. Large number of substoichiometric separation procedures have been developed covering most of the elements in the Periodic table and have been employed in RNAA wherever required.

Method for the Rapid Analysis of Industrially Important Alloys

Rapid methods have been developed for the analysis of Ag, V, Ti, Mn, Au etc. in alloys, jewellry, catalyst etc. The analysis was carried out employing ^{252}Cf as a neutron source followed by the measurement of the activity on a HPGe detector coupled to a PC based MCA. The time taken for the analysis was only 5 minutes.

Non-destructive Neutron Activation Analysis (NDNAA or INAA)

Instrumental neutron activation analysis is a very rapid and selective method involving the irradiation of the target with thermal neutrons followed by radioassaying of the irradiated sample and standard on HPGe detector coupled to a PC based MCA unit. The technique is non-destructive and hence precious samples can be analysed without dissolution. Neutron irradiation of ores, alloys, catalyst, animal tissue samples, biological samples, bone tissue samples etc. was carried out for the determination of Ga, Cu, Ag, In, Rh, Ir, Mn, Al, V, Ti, Sm, Eu, La, Dy etc. by INAA.

Besides, elements such as Co, Ta, Se, Fe, Zr, Yb, Cr, Tb, Zn, Sc, Cu, Tm, Ce, Th, Ho, Nd, Pr, Er, Sm, Nd etc. have been determined in a wide variety of complex matrices by INAA. Thermal neutrons from CIRUS or DHRUVA reactors at BARC have been employed for neutron irradiation and induced activity was measured on the HPGe detector coupled to a PC based MCA unit.

Achievements

The very good quality of research conducted in the Institute can be gauged by the fact that the staff of nuclear chemistry division have received many honours and distinctions at academic forums and students have won either merit certificates or prizes at the conference on nuclear and radiochemistry for their quality of research work and presentation. About 30 students obtained their Ph.D. and more than 10 students their M.Sc. degrees. Around 160 research papers have been published in journals of national and international repute.

The institute of Science, Mumbai hosted the DAE National Symposium on Radiation Chemistry and Radiochemistry and 3rd International Conference on Low level measurement of actinides and long-lived radionuclides in biological and environmental samples. The institute was also host for the BRNS-IANCAS National Workshop on Radiochemistry and Application of Radioisotopes.

The facilities of the nuclear chemistry laboratory are being utilised by a large number of staff and students from the Institute, Mumbai University, and different universities in India and other research centres. Lectures and experiments were conducted for college teachers attending the UGC sponsored refresher course in zoology, chemistry, botany, microbiology etc.

Acknowledgements

Grateful acknowledgements to the Government of Maharashtra for the generous financial grant for the construction of the new nuclear research laboratory.

Teaching and Research Activities at the Radiations and Isotopic Tracers Laboratory of G.B. Pant University of Agriculture and Technology

Dr. H.M. Agrawal obtained his M.Sc., M.Phi. and Ph.D. degreees in Physics from Aligarh Muslim University, Aligarh in 1973, 1975 and 1979, respectively. He had worked at various prestigious national/international institutes (I.I.T., Kanpur, NPD (BARC), State University, New York at Albany (USA), ORNL (USA), Dept. of Nucl. Engg., University of Michigan, Ann Arbor (USA) and GKSS Research Centre, Geesthact (Germany) as Visiting Scientist before joining G.B. Pant University of Agriculture and Technology, Pantnagar in 1985. His areas of research include nuclear reactions, resonance parameters and swift heavy ion irradiation induced effects in glasses. He has over forty-five publications in international/ national journals to his credit. Dr. Agrawal has also visited CERN (Geneva), BNL (USA) and ICTP (Italy) on academic missions. He is presently heading R.I.T.L., a central facility; and providing expert guidance in the applications of radioisotopes and radiation to the user community.

Dr. Surendra Kumar is research associate in Radiations and Isotopic Tracers Laboratory of G.B. Pant University of Agriculture and Technology, Pantnagar, U.P. He has been actively contributed to the applications of radioisotopes in a number of agriculture related activities.

Introduction

Radiations and Isotopic Tracers Laboratory (RITL) previously named Radio Tracers Laboratory at College of Basic Sciences and Humanities (CBSH), G.B. Pant University of Agriculture and Technology, Pant Nagar (U.S. Nagar) was dreamed and initiated by great visionary late Dr. D. Sharma in 1969 in a two-room space. He realized the necessity for development of Radiotracer Laboratory due to unique importance of radiations and radioisotopes in the modern agricultural and basic research. The Food and Agricultural Committee of DAE provided the necessary advice and guidance for the establishment of the laboratory. Instruments and other equipment necessary for radioassay, storage and safe handling of radioisotopes were provided under the U.S.A.I.D. and P.L-480 projects.

Due to increasing workload, separate building was planned and designed according to BARC expert's advice. The new laboratory building was ready in the summer of 1978. The laboratory has been built according to the international specifications of the Radiations Research Laboratory.

The RITL is duly approved B-Class Laboratory for handling radioactivity and functions primarily as a Central Research Facility for the different constituent Colleges of the University and also serves from time to time other sister institutions. It has emerged as an active central facility for interdisciplinary teaching and research in the basic, agricultural, veterinary sciences and biotechnology.

Main Functions at RITL

The main functions of the RITL are (i) to provide basic infrastructure to the University students and research scientists for the use of radioisotopes and radiation in their research and teaching activities, (ii) to train/educate the students/scientists of different departments for the safe and efficient use of radiations and radioisotope tracers for various applications, (iii) Procurement of radioisotopes and radiolabelled material from different suppliers for the users, (iv) Guidance in the planning and execution of radiotracer experiments, (v) Analysis and measurement of the radioactive

samples, (vi) Radioactive waste management, and (vii) Laison between the University departments and agencies such as BARC/BRIT/BRNS etc. of the DAE

Facilities Available for Teaching and Research

Equipment

(i) Liquid Scintillation Counter, (ii) Solid Scintillation Counter, (iii) Gamma Ray Spectrometer, (iv) Gieger Muller Counter, (v) Gas Flow type Proportional Counter, (vi) RIA-Gamma Counter, (vii) BF_3 Neutron Counter, (viii) Hands and Clothing Monitoring system, (ix) Radiation Survey and Contamination Monitoring Systems, (x) Plant Growth Chamber, (xi) Macro and Micro Autoradiography facility, (xii) Remote handling fume-hood, (xiii) Antimony-Berellium Neutron Howitzer.

Specialized Labs

(i) Soft beta lab, (ii) Gamma Lab, (iii) Autoradiography lab, (iv) Radiochemistry lab.

Miscellaneous

Facilities also exist for the safe radioisotope storage, remote controlling pipetting, radioactive-waste storage and disposal, radioactive sample digestion chamber and green house for experiments in plants.

Teaching

Postgraduate teaching is an integral part of the RITL activities. It offers the following P.G. courses every year to the P.G. students of the various departments.

(a) P.G. courses offered by the RITL

S.No.	Name of course	Course No.
1.	Radiochemistry	BPC-615
2.	The Uses of Radioisotopes in Research	BPC-616
3.	Radiotracer Techniques in Molecular Biology	BPC 617
4.	Radioisotopic Techniques in Mechanical Engineering.	BPC- 512

(b) P.G. courses, collaborated by RITL with other departments

S.No.	Name of course	Course No.
1.	Plant Nutrition	BPY-602
2.	Bioanalytical techniques	BPC-510
3.	Research Techniques in Plant Physiology	BPY-613
4.	Phytopathological techniques	APP-505
5.	Special problems in agronomy	APA-601
6.	Mutation Breeding	AGP-650
7.	Environmental chemistry	BBE/BPC-602
8.	Special Problems of Environmental Science	BBE-601
9.	Mineral nutrition of Crop Plants	AFA703
10.	Research Methods in horticulture	APH-703
11.	Bio-chemical Research Methods	BBC-710

The major topics covered in the P.G. courses are; nature of radioactivity, nuclear properties and reactions, interaction of radiations with matter, detection and measurements of radioactivity, counting errors and their remedies, radiation safety, radiation monitoring and decontamination, radiotracer principles, methodology and applications to the various fields of agriculture, veterinary, biological, basic and engineering sciences, advances in the solid and liquid scintillation counting techniques, isotopic dilution techniques, autoradiography, radioimmunoassay, neutron activation analysis and its applications, labelling techniques, radiolysis, dosimetery and synthesis/degradation of the labelled compounds.

Laboratory exercises include application of radioisotopes and radiation sources in the various fields of the mechanical engineering; such as measurement of thickness, rate of flow, leakage, wear of machine parts, tool wear, quality of lubricant and internal corrosion.

Study of biological effects of radiations include LD 50/30 concept, radiation sensitivity and target theory, labelling of biomolecules, radioactive waste

management and disposal, design and execution of radiotracer experiments.

Besides teaching, P.G. students of the University, faculty members also formulate and conduct short-term courses at the request of other institution's scientists/students for training in the above areas.

Research

Radiotracer techniques offer many advantages over the traditional methods. In many cases they are indispensable. Research has been actively pursued in different areas such as multielemental analysis of agricultural samples, soil chemistry, mineral nutrition and fertilizer utilization, soil water-plant relations, roots activity, photosynthetic efficiency and crop yield, pesticide's and herbicide's mode of action, biochemistry of sporulation, semen biology and animal reproduction, plants physiology and microbiology, biodegradation of labelled ^{14}C–lignocellulose by microorganisms and localization of nutrients and pesticides in crop plants by autoradiography. Main emphasis of research so far has been concentrated on the agricultural and veterinary productivity. In view of the exhaustive nature of the work, only the titles of the research activity along with published reference are given in this article.

Multi-Elemental Analysis of Soil Samples by Fast-Neutron Activation and PIXE

The elemental composition of soil, which is one of the main components of the environment and of the food production cycle, is of interest for researchers of the various science fields. Current universal interest in multi-elemental studies of soil samples are being spurred by our need to increase food, fibre, and energy production, evaluate bio-toxicity of elements, understand trace-element cycling in nature, monitor pesticides for high yield, and determine trace-elements of nutritional and/or toxicological importance.

Neutron activation analysis (NAA) has been used for the determination of major, minor, and trace elements in 20 soil samples from 5 crop fields of the Crop Research Centre, Pantnagar, India. Fast neutron activation analysis (FNAA) and cyclic neutron activation analysis (CNAA) have been used to determine the concentrations of various elements. The results for minor and trace elements were compared with the level of abundance of world soils. The present study [1] provided the basic data of elemental concentrations of soil samples of 5 major crop fields located in one of the leading agricultural universities of India for future measurements with the objectives of efficient use of fertilizers and pesticides in accordance with the high yield.

DST has approved a project to develop a regional PIXE facility at Punjab University, Chandigarh and G.B.Pant Univeristy, as user laboratory is looking forward to analyze agricultural samples by PIXE (Proton induced X-ray emission) too.

Soil chemistry/Mineral Nutrition and Fertilizer Utilization

Utilization of the fertilizer phosphorus in maize and legumes in the different soils supplied with different doses of P[2] ; Genotypic variability of zinc (A) value to soybean grown in mollisol of U.P.[3]; The fate of applied phosphorus in a mollisol of Nainital Tarai and its utilization in legume cereal sequence [4]; Correcting the Zn deficiency in Tarai crops by the application of Dimethyl Sulphoxide (DMSO) [5]; Uptake and distribution of ^{35}S and variations in growth yield and quality of sunflower in relation to sulphur nutrition [6]; Effect of zinc-phosphorus interaction on zinc nutrition (D-R-and-A-Values) in two differentially susceptible rice varieties grown in mollisol [7]; Studies on adsorption-desorption and supply parameter of zinc in soil in relation to nutrition and growth of rice [8]; Effect of DMSO on growth and zinc uptake by wheat [9]; Direct application of rock phosphate and low grade pyrite to soil [10]; The evaluation of supply parameter, a new index of zinc availability in mollisols [11]; Effect of different Fe-levels on zinc uptake and transport in maize seedlings [12]; Chemical kinetics, transformations and availability of phosphorus to rice plants under submerged soil conditions [13].

Soil Water Plant Relations and Roots Activity

Root distribution pattern of dwarf wheat as influenced by soil moisture regimes and nitrogen fertilization. [14]; Plant water use in wheat and

upland paddy [15]; Soil water, root relations in wheat [16]; Root distribution studies in Guava [17]; Root distribution studies in lemon cultivars [18]; Development of beta Gauging technique for moisture measurement of soil and leaf [19].

Photosynthesis Efficiency and Crop Yield

Radiotracer studies on photosynthetic efficiency and productivity of gram canopy, [20]; Studies on photosynthetic efficiency in Arhar [21]; Screening of wheat, rice and pulse germplasms for high photosynthetic efficiency, low photorespiration and high yield [22]; Studies on crop canopy and plant population optimization in sugarcane [23]; Photosynthetic efficiency of citrus cultivars [24]; ^{14}C-distribution in to various photosynthetic and photorespiratory metabolites under different osmotic stresses in the rice [25]; Interaction between SO_2 pollution and water deficit induced changes in photosynthesis, photorespiration and chlorophyll content in Sunflower and sorghum [26]; Physiology of sunflower (H. Annuus L) photosynthetic characteristics and yield potentials as modified by phytohormonal treatments [27].

Pesticides and Herbicide's Mode of Action and Translocation

An investigation on absorption, translocation and metabolism of 2,4-D-^{14}C in "lathyrus aphaca, melilotus indica and pisum sativum [28]; Toxicity, absorption, translocation and metabolism of 2,4-D-^{14}C in Phylaris minima L. [29]; Physio-chemical biological properties of metalaxyl (a systematic fungicide) [30] Pattern of uptake, translocation and distribution of ^{14}C-metalaxyl in pearl millet [31]; Mechanism of the translocation of metalaxyl and benomyl in fresh bean plants [32]; Study of the mode of action of herbicide pendimethalin in moongbean (*Vigna radiata* L., Wilezek) [33]; Binding of carbendazim by Lignin in Mango [34]; Uptake, Translocation, distribution and persistance of ^{14}C-metalaxyl in pea. [35]; Uptake Translocation and persistence of [Phenyl-UL-^{14}C] KTV-3616 in different plant parts of rice plants and mode of application [36].

Plant Physiology and Biochemistry

Investigations on the ion uptake, kinetics and interactions of $^{32}PO_4$, ^{45}Ca, ^{65}Zn, ^{63}Ni, ^{59}Fe and ^{35}S under different conditions in crops and oil seeds plants, role of inhibitors and promoters on the uptake and utilization of nutrients and biochemistry of the different enzymes, Co-enzymes and hormones and their role in the productivity etc. are routinely carried out. The important studies are; Radiotracer studies on the physiology and biochemistry of the micro-nutrient deficiencies in crop plants with particular reference to Zn deficiency [37]; Effect and mechanism of inhibitor's action on metal uptake during sporulation of B. Cereus T. [38]; Zinc and other metal interaction in pea (*Pisum sativum* L.) [39]; Effects of Zn nutritional levels on uptake translocation and Metabolism of ^{32}P in rice [40]; Kinetic studies on nitrogen induced uptake of ^{32}P by excised root system of maize [41]; Studies on uptake and transport of ^{59}Fe in maize seedlings at different Zn-levels [42]; Effect of zinc nutritional levels on uptake, translocation and metabolism of ^{32}P in wheat [43]; Influence of iron on uptake and transport of zinc in maize and wheat [44]; Zn requiring NADP dependent glutamate dehydrogenas from B. Cereus. T. [45]; Effect of DMSO on growth and zinc uptake by wheat [46]; Triptophan synthase in maize (*Zea mays* L.) *In vivo* and *In vitro* demonstration of enzyme activity [47]; Stimulation of synthesis and translocational activity of polyadenylated messenger RNA in wounded potato tuber by 2,4-Dichlorophenoxyacetic acid [48]; Modification of glutamine synthetase in Bacillus brevis [49]; Uptake and Kinetics of phosphate in excised corn roots [50]; Effect of zinc nutritional levels on growth and photosynthesis in chlorella pyrenoids [51]; Kinetics of zinc uptake by micorrhizal (VAM) and non-micorrhizal corn (*Zea mays* L.) roots [52]; Effect of nickel on growth and Photosynthesis of chlorela [53]; Nickel Toxicity : influence on growth, physiology and nutrient uptake in Dalbergia sissco and Eucalyptus hybrid seedlings [54]; Effect of water stress on the metabolism of ^{14}C-glycine in rice leaves [55]; Interaction between SO_2 pollution and water deficit stress; studies on photosynthesis, photorespiration and chlorophyll content in Sunflower and Sorghum [56]; Role of polyamines in salt resistance in rice and study of the Arginine decarboxylase inpolyamine biosynthesis [57];

Studies on microbial degradation of aflatoxin [58]; Studies on genotypic variation of zinc uptake and distribution in rice (*Oryza sativa* L.) [59].

Microbiology

The research work involves studies on bio-fertilizer development and utilization in various crops plants and forest species for increasing productivity in absence or partial replacement of chemical fertilizers. The studies are also aimed to find out toxic metal resistant and mineral nutrition promoting microbes for bio-pollution control and increasing agricultural productivity. The studies are also carried out for labelling of lignin by ^{14}C and its microbial degradation under various physico-chemical conditions with the aim of lignin utilization. Mention can be made of:

Multiphasic zinc uptake in mycorrhizal and non-mycorrhizal roots and french bean (*Phaseolus vulgaris* L.) [60]; Biodegradation of ^{14}C-lignocellulose by micro-organism [61]; Expression, Regulation and Purification of CSP of **PS** Fluorescens [62]; ^{14}C-(Lignin)-lignocellulose biodegradation by indigeneous microflora isolated from U.P. Tarai Region under different conditions [63].

Veterinary Science and Animal Nutrition

The research work in veterinary sciences is concentrated on animal nutrition, induction of artificial lactation through hormonal treatment in animals, development and utilization of RIA and ELISA based techniques for pregnancy testing in Cattle and Buffalo. Endocrine profile of Cattle and Buffalo have been established and Bovine Pregnancy diagnosis kit using progesterone level in serum or milk is developed. Other studies are; Uptake measurements of thyroidal ^{131}I in goat using autoradiography [64]; Variation in turnover of thyroidal ^{131}I in buffalo castration [65]; Effect of successive ejaculationon cytomorphology and biochemistry of bull and buffalo-bull semen [66]; Comparative studies on cytomorphology and biochemical constituents in the semen of Murrah, Red-dane Bulls, Nali Rams and Ja Munapuri bucks [67]; Comparison of progesterone level in defatte milk in pregnant and non-pregnant bovines through RIA and ELISA [68]; Post-partal hormonal profile of buffaloes and cows : Progesterone and Oestradiol -17B levels in defatted milk and developmentof a milk based Dot Blot immuno assay technique for bovin pregnancy diagnosis [69]; Concentration of steroid hormones in the follicular fluid of buffalo (*Bubalus bubalis*) during estrous cycle [70]; Effect of Gn RH alone or in combination with estrogen on reproduction parameters in post partum anestrous cows [71].

Miscellaneous Works

Development of parameters for the Cerenkov radiation detection technique for the measurement of ^{32}P-in plant leaves and roots [72]; Incorporation and labelling of ^{14}C-in lignocellulose and it's characterization [73].

Conclusions

The importance and utilization potential of the laboratory is reflected by the fact that 62 Masters and 33 Doctoral theses have been submitted so far based on the work carried out by researchers in a wide spectrum of disciplines with the facilities available in RITL. Besides this, laboratory has been instrumental in the execution of various internally and externally funded research projects. At present, twenty departments of College of Agriculture, College of Veterinary Sciences, College of Basic Sciences and College of Technology are utilizing RITL facilities for teaching and research purposes.

Acknowledgement

Authors are thankful to the users who have made their work available for this article. In particular, our special thanks are due to Dr. R.C. Pant (Dean, CBSH), Dr. V.S. Rathore, Dr. B.N. Johri , Dr. P. Singh, Dr. B.D. Lakhchaura, Dr. D.P.Mishra, Dr. P.C. Srivastava, and Dr. U.S. Singh for their expert comments and suggestions.

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Teaching and Research in Radiochemistry at Universities of Roorkee and Nagpur

Prof. Amar Nath Garg did his post graduation from Agra University in 1965 and obtained his Ph.D. from Indian Institute of Technology, Kanpur in 1970. Between 1974 and 1976 he was at University of Kentucky, Lexington, USA for his post doctoral research. Research activities of Prof. Garg include Mossbauer spectroscopy of iron compounds-structures and bonding studies, neutron activation analysis of biological and environmental samples, radiation chemistry of solid inorganic nitrates and aqueous systems: energy transfer mechanism. He guided 14 Ph.D. and 9 M.Phil. students. He has been with Nagpur University from 1979 to 1996, established a radiochemical laboratory there and carried out extensive research in radioanalytical chemistry. Currently, he is Professor in Chemistry, University of Roorkee, U.P. Prof. Garg has also been NASA Co-Investigator for analysis of Lunar sample, participated in many coordinated research project of IAEA. He also holds Japanese patent on multitracers. He was chemical abstracter to Chemical Abstractor Service, USA for 12 years. Prof. Garg is a member of many professional bodies and is also Vice-President of Indian Association of Nuclear Chemists and Allied Scientists.

Introduction

The author's association with University of Roorkee has been since September 1996 whereas he had spent 17 years of his active academic life at Nagpur University (from June '79 to Sept. '96). Accordingly three aspects namely teaching of radiochemistry course and radiotracer studies at the University of Roorkee and then author's own research activities carried out at the Nagpur University are covered in this article.

University of Roorkee

Perhaps many may not be aware that the University of Roorkee has been one of the oldest centres in the country where teaching of Nuclear and Radiochemistry course was started as early as 1963 when Prof. I.P. Saraswat trained at the University of Chicago, was specially brought in from BARC. Later in Jan' 68 Prof. S.N. Tandon, an analytical chemist trained in activation analysis and radiotracer work, joined this department.

Teaching Programme at Roorkee

During the past 35 years, a special feature of M.Sc. programme at this university has been a compulsory course on Nuclear and Radiochemistry. It is a one-semester course dealing with fundamentals of radioactivity including nuclear structure, interaction of radiation with matter and measurement of radioactivity, nuclear reactions, fission and applications of radioactivity. Also detailed features of radioanalytical methods such as radiotracer techniques including isotope dilution analysis and activation analysis methods are taught as a part of Analytical Chemistry specialization to M.Sc. final year students. Similar exposure on various radioanalytical methods is given to M.Phil. (Industrial Methods of Chemical Analysis) students as a part of a course on Instrumental Methods.

Besides teaching, students are also encouraged to do experiments using G.M.counter and scintillation γ-ray spectrometer. In the absence of any major facility such as a neutron source or Gamma Chamber, no advanced level experiments are conducted. However, an experiment based on the radiochemical separation of ^{234}Th from an uranium salt solution and determination of its half life is conducted. Some students are also encouraged to use radiotracers such as ^{51}Cr, ^{119m}Cd, ^{59}Fe etc. for physico-chemical investigations during their project work in fourth semester.

Radiotracer Work at Roorkee

Radiotracers have been extensively used for the partition studies of different solvent extraction

systems for metal ions. The data have been used for carrying various topical separations and proposing the relevant extraction equilibria. Labelled metal ion solutions have been used for the distribution studies on synthetic inorganic ion exchangers and thereby proposing various separations and the kinetics of exchange. The stability of the inorganic ion exchangers has also been tested against different gamma doses.

Shortly after joining the University Department, the author has initiated the use of radiotracers for the development of radiochemical solvent extraction methods for the determination of trace amounts of heavy toxic metals in environmental systems. Also efforts are being made for the development of isotope dilution analysis (IDA) and substoichiometric IDA methods using specific complexing agents and optimization of experimetnal parameters. Further work is being initiated on the determination of uranium and thorium in soils and plants by solvent extraction separation followed by radiometric measurements. It is planned to acquire a high resolution HPGe detector and start neutron activation analysis studies of medicinal herbs found in this region.

Research Activities at University of Nagpur

During the past two decades the author's independent research activities, started at the Nagpur University in 1979, have centered around three main areas, all using radioisotopes for various physico-chemical investigations. These research projects were financially supported by the Council of Scientific and Industrial Research, Department of Atomic Energy(BRNS), University Grants Commission, Indian National Science Academy and International Atomic energy Agency. This financial assistance enabled the setting up of a widely acclaimed radiochemistry laboratory at the Nagpur University.

Mössbauer Spectroscopic Studies using ^{57}Co Source

A series of pentacyanoferrates, hexacarboxylatoferrates, nitroprussides, dithiocarbamates and other complexes have been prepared. Mössbauer spectral studies of the complexes and their thermal decomposition products have provided useful information on their unique bonding and structural features. A correlation of parameters (and EQ) has been used to elicit electric field gradient in these complexes. Characterization of magnetic properties of some of these complexes has been a unique feature. Two research projects were supported by the CSIR on these studies.

Gamma ray Induced Decomposition using ^{60}Co Gamma Chamber

A large number of inorganic nitrates spreading over almost entire Periodic table including aqueous systems and organoiodides have been studied. Effect of cation size, its charge, electronegativity and polarizability on G-value has been investigated. An important aspect of these studies has been the effect of anionic impurities such as sulphates, carbonates, phosphates, borates and oxides causing enhanced G-values by several orders of magnitude. Some mixed double nitrates of alkali and alkaline earth metal nitrates with those of lanthanide and transition metal nitrates have been prepared to simulate processed nuclear fuel and their gamma ray induced decomposition was studied. Formation of transient species were identified by ESR, thermo-luminescence and other spectral measurements. These studies were supported by UGC and CSIR.

Development of Radioanalytical Methods

Neutron activation analysis and isotope dilution analysis were used for the determination of trace elements in a variety of geological, biological and environmental samples. This has been one of the most extensive fields of investigation at Nagpur University, with financial support from DAE, IAEA, UGC and IUC-DAEF. HPGe detector and 4k MCA along with other radiochemistry laboratory facilities were setup. Experimental parameters of irradiation, delay and counting times along with sample size were optimized and 20-30 elements were determined by employing INAA though in some cases radiochemical methods were also employed. Following types of samples have been analyzed.

(i) Dust particulates from industrial and metropolitan city environment, collected by Air Pollution Control Division of the National Environmental Engineering Research Institute (NEERI), Nagpur were analyzed. Fugitive and

ambient air dust particulates from a thermal power station, cement factory and paper mill were analyzed for 30 elements. Also ambient air dust samples from industrial, commercial and residential areas of Calcutta, Chennai, Cochin, Delhi, Mumbai and Nagpur were analyzed whereby anomalous elemental concentrations were attributed to specific industrial/anthropogenic sources.

(ii) Municipal solid waste (MSW) from metropolitan cities is often considered as a source of heavy metal pollutants. This work was also carried out in collaboration with Solid Waste Division of NEERI, Nagpur who provided authentic samples of MSW and sludges from various cities. Contents of heavy metals have been correlated with the city population, its technological advancement and industrial setup. Further, sludge samples from a treatment plant in Mumbai have been analyzed and role of the process in eliminating heavy metals was evaluated.

(iii) Paired samples of cancerous and normal breast tissues from four different histopathological stages and age groups were analyzed for 20 elements. Significant differences have been observed for Se, Zn, Cu, Fe, Mn, K and P but to different extent. It is observed that Se content is doubled in cancerous tissue whereas Fe, Mn and Cr are depleted. Further, blood samples of breast cancer patients, before and after operation were analyzed along with those of normal healthy women. Interestingly Se content in the blood of breast cancer patients is depleted. Data have been interpreted in terms of Se intake as its deficiency may trigger malignancy. Also it is the elemental ratios rather than pure elemental contents which seem to be more important.

(iv) Medicinal herbs, often used in Ayurveda for curing chronic diseases, have been analyzed for upto 25 elements. It has been proposed that several essential nutrient elements remain associated with organic macromolecules, and are easily absorbed by our body system. With this view in mind, large number of herbs and herbal medicines have been analyzed for minor and trace elements and data correlated with its therapeutic effects.

(v) Diet is the only source of essential nutrient elements for many biochemical processes in our body. In recent years there has been increasing awareness about elemental intake in various population groups. Therefore various dietary components such as cereals, fruits, pulses, vegetables, spices and cooked as well as raw diets as per recommendations of the National Institute of Nutrition, Hyderabad were analysed. On the basis of the analytical data generated, it has been found that elemental intake through typical Indian vegetarian diet is comparable to the Recommended Dietary Allowance (RDA) and our diet is in no way inferior to western non vegetarian diet. Further, milk formulations available in the market for children and adults have been analyzed for trace elements. Also natural milk from various origins (such as cow, buffalo, goat, mother) were analyzed and availability of essential elements from different sources was compared.

(vi) Hair composition has been often used as environmental indicator. Hair samples of industrial workers such as locomotive workers and welders along with those of controls from similar age groups have been analysed. It has been observed that some elemental contents specific to particular industrial origin are enhanced and others are depleted. Further, elemental composition of our population groups have been compared with those from other countries.

(vii) A variety of fish from different coastal regions (Visakhapatnam in east, Mumbai in west and Mangalore in south) were analyzed for nutrients and heavy metal toxic pollutants. Since coastal population is wholly dependent on fish as their principal diet and export regulations require strict quality control, it is essential to analyze fish from various regions. Further, elemental data of Indian fish have been compared with those from other countries.

(viii) Since many important industries and technical institutions such as Mineral Exploration Corporation Limited, Manganese Ore India Ltd., Geological Survey of India are located in

Nagpur, an attempt has been made to use the 5 Ci ^{241}Am-Be source available in the department for the analysis of major constituents of various ores. Thus Al, Fe and Si were determined in bauxite, Mn in pyrolusite and Cu in chalcopyrite without dissolving the sample. The data were found to be comparable with those obtained by classical chemical and instrumental methods.

(ix) Nagpur University has participated in intercomparison run studies for the development of suitable Standard Reference Materials by International Atomic Energy Agency and similar agencies from other countries. The data obtained for several candidate reference materials have been found in acceptable limits and the nuclear and radiochemistry laboratory at Nagpur University was adjudged for the certification of elemental contents.

Radiochemical solvent extraction procedures were developed for several elements such as Fe, Co, Zn, Mn, Cr, Sb, Se, Mo, Ta, Cd, using respective radiotracers. Further, IDA and substoichiometric IDA have been employed for the determination of these elements in complex matrices of biological and environmental origin. Also some RNAA methods have been developed for the determination of trace and ultratrace amounts of these elements. A method for the development of P in biological samples, based on neutron irradiation followed by counting, was developed.

Achievements and Honours

An important feature of the research activities carried out at Nagpur University has been due recognition at the national and international level. Eight students completed their Ph.D. on NAA related projects. Many of the research students were awarded cash prizes or certificates for best paper presentations at DAE symposia held at various places. A good number of them are carrying out postdocoral research at prestigious laboratories abroad. Two Coordinated Research Projects (CRP) sponsored by the International Atomic Energy Agency (IAEA), Vienna were awarded to the author during his tenure in Nagpur. A total sum of US $ 30,000 was granted and it helped in augmenting the infrastructure facilities at the Nagpur University. Also it helped the author to meet stalwarts from various countries at the meetings organized at Warsaw (Poland), Rome (Italy), Vienna (Austria) and Florida (USA).

A DAE symposium on Radiochemistry and Radiation Chemistry was organised in February 1990. Also a National Workshop on Radiochemistry and Applications of Radioisotopes was organised by IANCAS during July 1992. At the same time a National Seminar on Atomic Energy Programme was organized in collaboration with INS. At Roorkee, a one day workshop on Nuclear Energy; Health and Safety Aspects and an exhibition on "Atom for Peace" sponsored by the Nuclear Power Corporation Ltd. was organised.

Conclusions

While infrastructure facilities for carrying out radiochemical research exist at University of Nagpur, it is not the case with Roorkee University. For a meaningful research, facilities such as high-resolution gamma spectrometry are essential. Efforts will be made to procure the same.

Acknowledgements

I am indebted to Prof. P.S.Goel who introduced me to this exciting subject and Prof. W.D. Ehmann for creating interest into vast areas of research in this field. My academic growth in Nagpur has been due to active help of my well wishers and friends like Drs. Satya Prakash, D.D. Sood, S.B. Manohar, M.D. Sastry, A.V.R. Reddy, P.P.Burte, to name a few. I also thank all my research students who tolerated me and helped in contributing a bit. Each one of them also carried out short irradiation experiments using APSARA and CIRUS reactors at BARC.

Teaching and Research in Nuclear Chemistry and Allied Sciences in Vikram University, Ujjain

Dr. S. Mukherjee obtained his M.Sc. (Physics) and Ph.D. (Nuclear Physics) from Banaras Hindu University, Varanasi in 1982 and 1989, respectively. For a brief period, he worked as a Project Scientist in the Physics Department, Indian Institute of Technology, Kanpur. He joined the School of Studies in Physics, Vikram University, Ujjain as a Lecturer in 1990. At present he is a Senior Lecturer in the same department. He has been working in the field of intermediate energy charge induced nuclear reactions. He has fifty publications in journals of international repute, conferences, symposia etc. to his credit.

Introduction

Vikram University came into existence on October 23, 1956 in the historic city of Ujjain with vast jurisdiction covering entire Madhya Bharat and Bhopal as affiliates. Dr. Mata Prasad Mathur, a great scholar of chemistry was chosen as the founder Vice-Chancellor. The Vice-Chancellor conceived the idea of various Schools of Studies in Science. The University at present is imparting education in ten faculties viz. Arts, Social Sciences, Physical Sciences, Life Sciences, Commerce, Law, Education, Engineering, Management and Ayurveda.

A modern academic institution of learning depends on its department of Sciences for the simple reason that, today's development in sciences provide tomorrow's technology. The more advanced courses and research activities have close linkage with the development programs in more applied disciplines. The School of Studies in Sciences namely Physics, Chemistry, Botany, Zoology and Geology is proud to take care of both these roles adequately in addition to being known in the country for research activities pursued by several reputed researchers.

Teaching Activities

School of Physics

The School of Studies in Physics has a team of nine faculty members, who are interested to promote the research and training programmes of the current national needs and interests as emphasized in the new education policy. The program of study consists of teaching of M.Sc. courses. Besides, the department has one year M.Phil. course. Out of the eight theory papers in the M.Sc. course, one paper is completely devoted to Nuclear physics. This paper includes topics like basic nuclear properties and forces, radioactive decay, nuclear reactions, fission, fusion reactions, nuclear models, two body problems and elementary particle physics etc.

School of Botany

The topic of radiation induced mutations is covered along with cytogenetics and genetics in M.Sc. final year course. Students are familiarised with basics of techniques and methods used for studying radiation induced chromosomal aberrations and induced mutants. To strengthen the above, the students are also required to do some practicals. They are provided with irradiated seeds and are advised to understand the effect of radiation on chromosomes following standard protocols.

School of Geology

M.Sc. (final) and M.Sc. (Tech) Geology courses cover (i) mode of occurrence, distribution and genesis of minerals used for nuclear energy in India and (ii) radioactivity of rocks and minerals. Field procedure, measurement and interpretation of results for mineral prospecting.

School of Chemistry

In the final year of M.Sc. a part of the general physical chemistry paper includes nuclear chemistry having topics like, basic properties of nuclei, Nuclear reactions, Fission, fusion, various counters and radioactive technique. Another special paper is exclusively devoted to nuclear chemistry. This paper

includes, besides, nuclear properties and forces, the interaction of radiation with matter, detection equipment, accelerators, radioactivity and errors in radioactive measurements. This paper also includes nuclear reactions, fission, fusion, radiation hazard and protection, nuclear reaction dosimetry.

Research Activities

The research and teaching activities in Nuclear Sciences and related fields have been carried out by young faculty members in almost all branches of sciences in the University, who are assisted by research associates and several Ph.D. scholars engaged in doctoral research.

School of Physics

Charged Particle Induced Nuclear Reactions

The experimental nuclear physics group is headed by the author. The work done in the field of experimental nuclear physics, using various national facilities by the group in the university is rather enormous and it is not possible to do justice in a limited space. However, an inkling of the work in recent years is presented.

Pre-equilibrium reaction mechanisms have been analyzed in order to explain a wide range of excitation functions induced by alpha particles up to 120 MeV. A large number of targets with different mass numbers (V, Co, Ni, Ag, In, Nb, Y, Ho, Tm, Au to name a few) were studied by the well known activation technique and Gamma ray spectroscopy. The irradiations were carried out at the Variable Energy Cyclotron Centre, Calcutta. Excitation functions for the reactions involving nucleon and alpha particle emission were measured experimentally and the results were compared with those obtained using various semi-classical theoretical models to interpret the results in terms of pre-equilibrium reaction mechanism.

With the commissioning of the two pelletrons at TIFR, Mumbai and Nuclear Science Centre, New Delhi, the activities of the group shifted to these centres to a large extent A large number of experiments have been performed with various beams delivered by both the machines. Complete and Incomplete fusion reactions at projectile energies 4-7 MeV/nucleon have been studied for various systems like $^{16}O+^{51}V$, $^{12}C+^{89}Y$, $^{12}C+^{103}Rh$, $^{12}C+^{115}In$, $^{12}C+^{169}Tm$, $^{16}O+^{93}Nb$, $^{16}O+^{165}Ho$ etc., by the excitation functions and recoil range distribution measurements. The study of linear momentum transfer from projectile to target in the above heavy ion reactions was used as a tool to distinguish between the mechanisms which dominate the collision dynamics, ranging from complete fusion(CF), incomplete fusion(ICF), to more complex multibody pre-compound processes. Comparison of the experimental data with the predictions of Monte Carlo Simulation code PACE 2 for complete fusion was used to deduce the incomplete fusion component in the recoil range distributions. From the relative yields of the incomplete fusion products, the excitation energy and angular momentum of the incompletely fused composite were deduced. Most of the above-mentioned work has been published in journals of international repute.

Collaborative Programs Undertaken Since 1994

The author has a joint programme with Radiochemistry Division BARC, Mumbai to study the various mechanisms, namely, incomplete fusion, deep inelastic collisions and complete fusion etc., involved in the heavy ion induced reactions in the beam energy range of 10 MeV/nucleon. several on-line experiments will be performed with both the pelletrons and using the heavy ion facilities at VECC Calcutta. Recently, the Board of Research in Nuclear Sciences (BRNS), DAE, has sanctioned a major project of Rs. 20 lakhs to the author in collaboration with senior scientists from BARC.

School of Botany

Gamma Ray Induced Damage to Chromosomes /Nuclei

Dr. R.C. Verma, Reader, Institute of Environmental and Plant Sciences, and his research scholars are engaged in the study of gamma ray induced damage to chromosomes/nuclei and production of useful mutants in some economically important plants like *Phlox drummondii* an ornamental, *Vicia faba* a legume and *Crotalaria junca* a green manure crop. The seeds of these plants are subjected to 5kR, 10kR, 15kR, and 20kR doses of gamma rays (source ^{60}Co) at the National

Botanical Research Institute, Lucknow. Some of the irradiated seeds are germinated on moist filter papers in petriplates and the root tips, after proper staining with chromosomal dyes are used for squashing to study mitotic chromosomal aberrations. These aberrations are categorised according to standard classification and dose - response, relation to cell cycle etc. are studied. Some of the irradiated seeds are sown in the pots to raise the M_1 plants which are screened for mutants/variants. If mutants are induced, these are isolated, self fertilized and used for raising next generation M_2, M_3 and so on to study the inheritance of changed trait.

School of Geology

Geological Mapping and Radiometric Surveys

As a part of his research project, the Principal Investigator, Dr. R. Krishnamurthi and his group in School of Studies in Geology carried out Geological mapping and radiometric surveys using portable Scintillator provided by Atomic Minerals Division at Gauthama prospect, Bethul district, M.P. The study area is located (77° 50'30"N-77°55'15"N; 22°0'E-22°50'E) 6 Kms north east of Bethul town.

Four traverses trending NE-SE were undertaken across the hills covering all rock types. A total of 60-65 stations were selected with 10 m interval in a grid pattern for scintllometer reading. Radioactivity of each station was recorded by instrument and the range of values are given below:

Rock Type	Scintilometer reading (mR/hr)
Meta basic rocks	0.1
Mica schist	0.1-0.2
Graphite schist	0.2-0.7
Arenaceons Mica schist	0.35
Granite/Gneiss/Quartz vein	0.35-6.0

An isorad map was prepared by plotting all the values and connecting values of equal radiation. This map indicated a highly radioactive zone (with 5 to 6 times more than background values) which needs more attention. Work is on to establish the genetic aspects of this area for uranium mineralization.

Achievements

Recently, a ten day National Workshop on Radiochemistry and Applications of Radioisotopes was organized in the School of Studies in Physics, by the Indian Association of Nuclear Chemists and Allied Scientists (IANCAS) of Radiochemistry Division in February 1999. A number of research papers from different schools have been published in international journals.

Conclusions

Teaching and research in the field of nuclear and allied sciences is an interesting phenomenon. The University departments are gradually picking up the threads of this exciting branch of science and to nurture, develop and advance the appropriate concepts for the benefit of the students and the researchers and also for the betterment of the society at large.

Acknowledgements

The author wishes to thank Prof. R.K.S. Chauhan, Vice Chancellor, Vikram University, Ujjain for his keen interest and cooperation in preparing this article. Thanks are also due to the Heads of all the Schools of Studies in Sciences for their help. Thanks are also due to my colleagues, Prof. S.K. Ghosh, Dr. R.C. Verma, Dr. R. Krishnamurthi and Dr.(Mrs.) Uma Sharma from School of Studies in Physics, Botany, Geology and Chemistry, respectively for their suggestions and help.

For Limited Circulation Only

Published by
Dr. K.L. Ramakumar, Secretary, Indian Association of Nuclear Chemists and Allied Scientists
(Registration No. MAH /232/1984 GBBSD) C/o. Radiochemistry Division, Bhabha Atomic Research Centre, Mumbai 400 085

Printed by
Perfect Prints, 22/23, Jyoti Industrial Estate, Nooribaba Darga Road,Thane 400601. Tel : (022) 534 12 91

Edited by
Dr. M.R.A. Pillai, Radiopharmaceutical Division, Bhabha Atomic Research Centre, Mumbai 400 085