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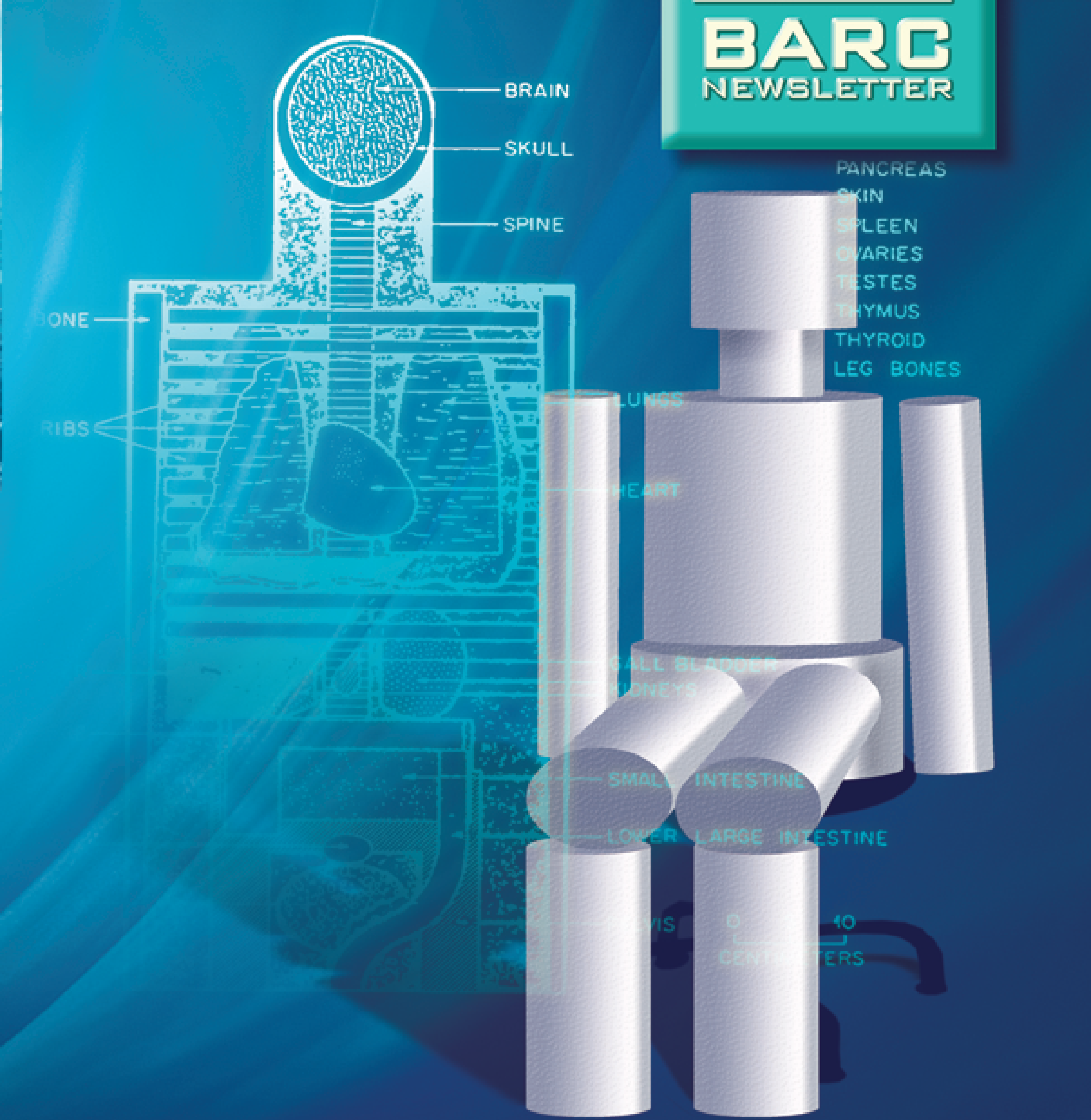

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RADIATION TECHNOLOGY-ENABLED MARKET ACCESS TO INDIAN MANGO - JOURNEY FROM DEOGARH TO DC

In the forthcoming issue

Each year, the October issue of the BARC Newsletter is dedicated to the memory of Dr. H. J. Bhabha, the architect of BARC. It is thus a Founder's Day special issue. It carries all award winning articles either presented by BARC Scientists and Engineers at various symposia, conferences or for their outstanding contributions in their respective fields, during the preceding year.

This year too, the October issue will carry such award winning articles.

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RADIATION TECHNOLOGY-ENABLED MARKET ACCESS TO INDIAN MANGO - JOURNEY FROM DEOGARH TO DC

Arun Sharma
Food Technology Division, BARC

It has been a long journey, both for food irradiation R&D as well as the King of fruits, the Indian Mango, to make it to one of the world's most sought-after markets, the USA. India is the world's largest producer of mangoes, with a production of about 12 million metric tonnes, but accounting for less than 1% of the global mango trade; Maharashtra being a leading state that showcases it's most sought-after variety, the King Alphonso. Another top variety of the region is Kesar, the Queen. One can only tell the difference between the Indian mango and those from the rest of the world, if one really had the opportunity to actually taste them. America's taste for mangoes is growing, with 99% of the demand of nearly 250,000 metric tonnes, valued at around $ 156 million. It is met mostly by imports from Mexico and South America. In contrast, India exports only around 58,000 metric tonnes. Of which this year India exported a meagre 275 tonnes to USA, which is nearly double the quantity exported last year. It is the radiation technology and the R&D efforts in BARC of the past several years, that made it possible to overcome the quarantine barrier, imposed by USA and which had denied market access to the Indian mango, for the past 18 years. Thus there is a huge unt apped potential.

R&D

Mango is a fruit of the tropics. Physiologically, it displays a typical climacteric behavior, which is characterized by a post-harvest peaking (climacteric) of respiratory activity and simultaneous production of the ripening hormone ethylene, and a pre-climacteric dip (Fig. 1).

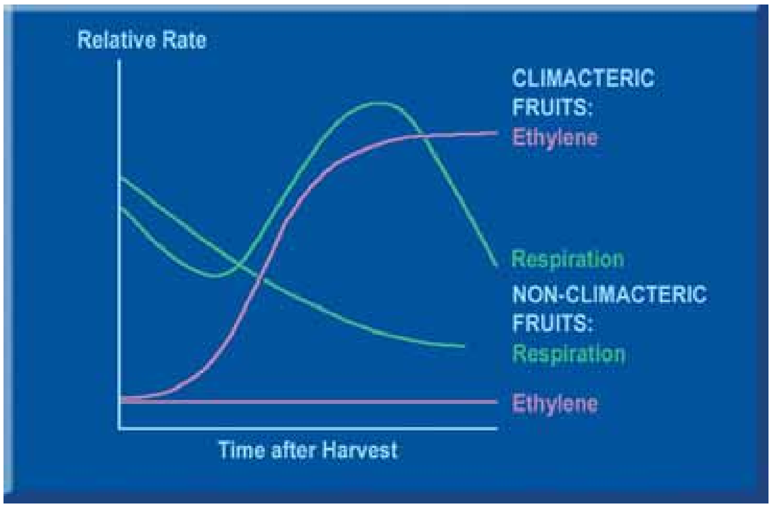

Fig. 1: Respiratory activity and ethylene evolution in climacteric and non-climacteric fruits

In BARC, Prof. Sreenivasan and Dr. Dharkar initiated studies on the evaluation of effects of gamma radiation on tropical fruits, in the early sixties including mango. Initial experiments were carried out using a small irradiation equipment Gammacell-220. The delay in ripening of about a week, observed in mangoes exposed to low dose of 250 Gy and stored at ambient temperature of 25-30 °C, was quite remarkable and had potential commercial application in India. These studies were published in well-known scientific journals (1-4). A few years later, the efficacy of irradiation for disinfestation of fruits, killing of fruit flies and stone weevils, for overcoming quarantine barriers with similar doses was also demonstrated (5-7). It was found that the best results were obtained, when mangoes were irradiated at a hard mature stage (80% maturity), during the pre-climacteric phase.

During seventies, as a result of publication of some studies, doubts about the wholesomeness and nutritional adequacy of irradiated foods, led to uncertainty about the continuation of food irradiation programmes around the world. Of course, these studies were later disproved and discarded and R&D on food irradiation was resumed. In the intervening period, many a researcher shifted focus of his research to base-line studies on food commodities, including mango. There were several studies reported from BARC on the flavour and aroma components of mango, both raw and ripened (8-17).

International approval

In 1980, a FAO/WHO/IAEA Joint Expert Committee on Food Irradiation (JECFI), after evaluating data on wholesomeness and nutritional adequacy of irradiated food, available till then from reputed laboratories of the world, including BARC, clearly concluded, that irradiation introduces no radiological or toxicological hazards or special nutritional or microbiological problems (18,19). This paved the way for research activity oriented toward commercial exploitation of the technology (20-22). In 1994 an Expert Group constituted by the World Health Organization (WHO) once again reviewed the wholesomeness data available till then and endorsed the earlier conclusion of JECFI (23). In 1997, another Expert Group constituted by WHO affirmed the safety of food irradiated to doses above 10 kGy (24). In 2003, Codex Alimentarius Commission, the apex world body for food standards, revised it's Codex General Standard for Irradiated Foods, to include application of doses higher than 10 kGy. The agreements on Sanitary and PhytoSanitary (SPS) Practices and Technical Barriers to Trade (TBT) under the World Trade Organization (WTO), provided for adoption of irradiation as an SPS measure in international trade, under the principle of equivalence. In 2003, IPPC included irradiation as a plant quarantine treatment. This was subsequently followed by the publication of final rule, "irradiation phytosanitary treatment of imported fruits and vegetables", by the United States Department of Agriculture-Animal & Plant Health Inspection Service (USDA-APHIS).

National approval

In 1986, the Government of India set up a National Monitoring Agency to oversee the commercial application of radiation processing of food. The Atomic Energy Act was amended in 1991 and the Atomic Energy (Control of Irradiation of Food) rules were published and later amended in 1996. The department is again amending these rules, for according generic, class-wise approval for radiation processing of food and allied products. In 1994, the Government of India amended the Prevention of Food Adulteration Act (1954) Rules and approved irradiation of onion, potato and spices for domestic market. Additional items including mango were approved in 1998 and 2001. The Ministry of Health & Family Welfare further amended these rules, and a notification has already been issued approving irradiation of food based on generic class-basis.

In 2004, on the request of BARC, the Ministry of Agriculture & Co-operation, Government of India, amended the plant quarantine regulations and published, "Plant Quarantine (Regulation of Import into India) Order, 2003", to include irradiation as a phytosanitary treatment. This enabled in February 2006 the signing of a Frame Work Equivalence Work Plan agreement between USDA-APHIS and the Ministry, that set in motion the process for using radiation as a phytosanitary treatment for mango exports to US. Though the negotiations between the Department of Agriculture & Co-operation (DAC), Government of India and the USDA were initiated as early as 2004, the USDA-APHIS final rule "Importation of Mangoes From India" was published only on March 12, 2007.

It must be noted here, that in India, under the current rules only mango is approved for radiation processing in the fresh fruit category. On the other hand, under the US regulations, fresh fruits and vegetables as a generic class have been approved for radiation processing up to a dose of 1 kGy. It is for this reason that BARC has been pursuing generic class-based approvals from the regulatory authorities in India. Moreover, once a generic class-based approval is accorded, other fruits and vegetables can also be processed by radiation. Also, increasing the range of commodities for radiation processing, will go a long way in improving the year long availability of feedstocks for irradiation plants, improving their economic viability.

Challenges of commercial irradiation

KRUSHAK (Krushi Utpadan Sanrakshan Kendra), Lasalgaon, was set up during IX plan (1997-2002) by the Food Technology Division, BARC, as a technology demonstration facility for low dose applications of radiation, such as control of sprouting in onion and potato, insect disinfestation of cereals, pulses, their products, spices and quarantine treatment of fresh fruits and vegetables. The Division of Remote Handling and Robotics (DRHR) of BARC was the designer of the facility. It is the only facility in India truly designed for this purpose. The facility was inaugurated on October 31, 2002 by the Prime Minister Atal Behari Vajpayee, from BARC, Mumbai and till 2007 was being mainly used for processing of onion, for sprout control during storage.

USDA-APHIS Inspectors at KRUSHAK

KRUSHAK product box with mango cartons ready for irradiation

KRUSHAK was the only facility that was recognized by USDA-APHIS, that could be retrofitted for quarantine treatment of mango. One of the important aspects of the proposal to export mango to USA, was the Facility Compliance Agreement to be signed between the USDA-APHIS and on our behalf by the Department of Agriculture and Co-operation (DAC), Government of India. It meant that KRUSHAK should meet all the compliance requirements of the USDA for quarantine treatment. Only after satisfying itself on all accounts, USDA would issue a certificate of approval to go ahead with the commercial processing of mango.

Advantage teamwork

Developing and implementing protocols for full-scale commercial operation for quarantine treatment of mango, posed several challenges.

KRUSHAK Team

A mango carton and cut mango after reaching USA and below the US Secretary of State receiving a basket of mangoes from Mr. Sanjay Baru, Media Advisor, PMO.

The exercise was totally different from the protocols used in laboratory experiments or even in pilot plant irradiators and needed dedicated efforts of our colleagues Dr. Ramesh Chander and staff at KRUSHAK to standardize protocols. The Operational Work Plan and the Standard Operating Procedures (SOPs) were written, rewritten and vetted at several stages. The Operational Work Plan, the SOPs and the Facility Compliance Agreements were finally forwarded to DAC, for submission to USDA-APHIS.

In the first week of April 2007, after signing of the Operational Work Plan agreement, a team of USDA-APHIS inspectors descended upon KRUSHAK to check ground compliance. It was a difficult task making an onion irradiation facility spic and span, free of flying and crawling insects fit for quarantine treatment. Because of the peculiar requirement of 400 Gy as the minimum dose for quarantine treatment and the lack of a standard dosimeter appropriate for that range, it was equally difficult to standardize the dosimetry protocol and demonstrate it's applicability to the satisfaction of the USDA inspectors, a work well accomplished by Ms. Kalpana Khedkar of BRIT. The USDA inspectors used ESR-film dosimeters, sent irradiated dosimeters to NIST, USA, for inter-comparison. Finally, a correction factor was employed to fix the cycle time of the irradiator. Another major hurdle was the availability of broadband Internet connectivity at Lasalgaon, a rather remote village, which was achieved with great difficulty by a vendor from Nashik. The officials of DAC and APEDA eagerly awaited the results of our compliance.

Finally, on April 26, 2007 the USDA inspectors after completely satisfying themselves issued the much coveted certificate of approval. A trial consignment was immediately dispatched to New York. This was followed by a week of wait for the results and all indications turning positive, the commercial irradiation started from the second week of May 2007. The feat could be accomplished with the all out encouragement of authorities in DAE, DAC, APEDA, BRIT and BARC, and untiring efforts of the ground staff.

KRUSHAK became the first cobalt-60 gamma irradiation facility in the world, outside US, to be certified by USDA-APHIS for phytosanitary treatment of mangoes, enabling export of mango to the US after a gap of 18 years. Last year 157 MT of mangoes were exported to USA, where as the volume approximately doubled this year. It is a tribute to the years of hard work of several scientists and engineers of BARC and the dedicated efforts of the officials of the different department of the governments of the two countries.

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UPGRADATION OF INTERNAL DOSIMETRY FACILITIES AT BARC, TROMBAY

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INTRODUCTION

Monitoring of occupational workers for possible internal radioactive contamination, is an important part of a comprehensive radiological surveillance programme. Body Burden Measurement (BBM) and Bioassay and Biokinetics (BB) Sections of the Health Physics Division (HPD) BARC, are responsible for carrying out internal contamination monitoring of occupational workers at BARC, Trombay using *in-vivo* (direct) and/or *in-vitro* (indirect) measurements as applicable. Direct measurement techniques viz. whole body counting, thyroid counting and lung counting are used, to estimate internal contamination due to fission products, activation products and actinides that emit x or g ray photons. In the indirect method, urine or faeces of the occupational worker is analyzed, to determine excretion rate from the body of internally deposited radionuclides, which are pure b or a emitters. Results of both the measurements are used, to estimate Committed Effective Dose (CED), using appropriate biokinetic model and internal dosimetry software. For estimation of internal contamination due to actinides in lungs, dual phosphor detector (phoswich) installed inside a steel room at BARC Hospital has been in use, for the last 30 years. In addition to this, recently we have installed a state-of-the-art system for lung counting, which uses HyperPure Germanium (HPGe) detector as has been done at most of the internal dosimetry laboratories around the world.

In the years 2002-06, we participated in an IAEA intercomparison exercise called 'Intercomparison of radiological measurements for monitoring purpose– Direct Measurement of Radionuclides, in Simulated Organs'. Under this exercise Knee, JAERI, BOMAB and Thyroid phantoms (representing human body/organs) distributed with unknown amount of radionuclides, were received. Measurement and estimation of each radionuclide were carried out, using appropriate detection system and results reported to IAEA. In the year 2005, the division also participated in IAEA web-based workshop viz. "Intercomparison exercise on internal dose assessment" called IDEAS. This web based intercomparison exercise consisted of six cases covering wide and complex exposure scenarios for internal dose calculation. These cases were solved using various dose evaluation software and results reported to IAEA. Monte Carlo techniques have been employed, for calibration of various direct monitoring systems, using size-dependent mathematical phantoms, representing Indian and ICRP reference man. Computer software was developed/ procured for biokinetic studies of various radionuclides, using the latest Human Respiratory Tract (HRT), Gastro Intestinal Tract (GIT) and element specific biokinetic models.

In the indirect methods, Fission Track Analysis (FTA) technique has been standardized, to detect ultra trace levels of U and Pu in urine and faeces. Thoron-in-breath measurement technique, for estimation of internal contamination due to thorium, has been standardized for regular use. The division has initiated intercomparison exercise for response of shadow shield bed, whole body counters, in operation at various DAE facilities. All these activities have helped in upgrading and strengthening of internal dosimetry infrastructure at BARC Trombay. A brief report of these activities is given in this article.

UPGRADATION OF LUNG COUNTING FACILITY

Permissible limit of intake through inhalation for actinides such as U, Pu and Am for an occupational worker is very low. The direct method of measurement of internal contamination due to these radionuclides, is based on the measurement of activity in lungs, by measuring x/g ray photon emission from them.

Detection of Low Energy Photon (LEP) emitting radionuclides like ^{239}Pu (17 keV), ^{241}Am (60 keV), and ^{238}U (63, 93 keV) in human lungs, at the desired detection level, is rendered difficult due to low yield of their photons and their significant attenuation / absorption in the lungs and the chest wall. For this purpose, specialized radiation detectors with large area, good energy resolution and very low background are required. In order to reduce detector background, measurements have to be carried out inside totally shielded massive steel room (weight 100- 150 tons) with optimized shield thickness of about 20 cm. Further reduction in the background of the detector at the region of interest is achieved by lining the inside of the steel room with graded Z material viz. 3 mm Pb + 2 mm Cd + 0.5 mm Cu in this order.

As the background of the detector is dependent on the thickness/ volume of the detector, earlier thin NaI(Tl) detectors of 200 mm diameter and a few mm thickness (3 to 12 mm depending on application) were employed. Later on, in early seventies, to further reduce the background of these thin detectors, a new type of detector known as 'phoswich detector' was developed. Phoswich is a combination of a thin primary NaI(Tl) (3 to 12 mm thick) and a thick secondary CsI(Tl) (50 mm thick) coupled to three photomultiplier tubes. Difference in the decay times of the two scintillators is used, to reduce the background of the primary thin detector by about a factor of ten, by using pulse shape discrimination technique. A lung counting facility using phoswich detector is in operation at BARC Hospital for more than thirty years, for routine monitoring of radiation workers.

In mid eighties, array of planar HPGe detectors was developed by some laboratories abroad. Although the detection area of these arrays was much lower as compared to 200 mm diameter phoswich, their inherently superior energy resolution, more than compensated for their smaller area, as the identification of the radionuclides was possible at much lower level of radioactivity. However these systems were prohibitively expensive and because several liquid nitrogen Dewars had to be used for cooling the detectors in most of them, their positioning over the human chest was considered to be little complicated. Moreover, the energy resolution of planar detectors was relatively poor as compared to the expected value and they were not considered as rugged as coaxial HPGe detectors, used for High Energy Photon (HEP) detection (^{137}Cs, ^{60}Co, ^{131}I etc). In the late eighties / early nineties, an improved technology of growing coaxial HPGe detectors was used, to develop larger diameter crystals with lower thickness. This special coaxial geometry, resulted in a reduction of detector capacitance compared with the earlier conventional 51 mm dia. planar detector. This reduction in capacitance helped in improving energy resolution compared with the best available planar detector. These detectors were designated as LOAX HPGe detectors.

The superior geometry of LOAX detectors, provides lower noise, superior energy resolution, high peak to background ratio and much lower background continuum. Another noteworthy development took place towards the end of the last decade, when 3 or 4 crystals of 70 mm dia. each of LOAX HPGe could be sealed in a disc-like vacuum tight enclosure and cooled to liquid nitrogen temperature, by attaching them from a side to a single large size Dewar. This has considerably improved the convenience in using these systems for routine monitoring of radiation workers. As a result of these developments, the cost of these systems also came down and they became more affordable.

Fig. 1: LOAX HPGe detector and JAERI phantom in counting position inside the steel room

We have procured a state-of-the-art system which comprises three (70 mm dia. x 25 mm thick) LOAX HPGe detectors in one enclosure, with side connection to a single 30 litre Dewar which is kept on a platform fixed to the wall of the steel room. The detector has 0.8 mm thick carbon entrance window, which can transmit all photons above 10 keV energy, to active area of the detector. The signal from each detector can be analyzed separately as well as in any combination with other detectors. The spectrum of individual detector is used, to obtain information about the distribution of the contaminant in the lungs. For this purpose, three separate MCA cards are used. Figs. 1 and 2 show an array of LOAX HPGe, installed inside steel room for lung monitoring of radiation workers. The detector system is movable vertically and the bed can be moved in all the three directions, for positioning of the detector above the chest of the subject to be monitored.

Fig. 2: A person is being monitored for lung contamination using LOAX HPGe detector.

The average energy resolution (FWHM) of the three detector system at 17 keV (^{239}Pu), 60 keV (^{241}Am), 63 keV (^{238}U), 93 keV (^{238}U) and 185 keV (^{235}U) is measured to be about 505, 650, 590, 740 and 730 eV, respectively. The energy resolution of 650 eV for ^{241}Am (60 keV) may be compared with the resolution of about 12 keV, obtained with phoswich detector. The excellent resolution and good sensitivity of the LOAX detector system provides a more accurate assessment of internal contamination of low energy X-rays/ g-emitting actinides of interest, even in presence of other gamma emitting radionuclides. Keeping in view these advantages, we have planned to use LOAX HPGe system for special monitoring and continue to use phoswich for routine monitoring. The calculated minimum detectable activity (MDA) of LOAX HPGe system for a monitoring period of 3600 sec is 4 and 5 Bq for ^{241}Am and ^{238}U, respectively. Fig. 3 shows the spectra for ^{241}Am recorded with LOAX HPGe detector.

Earlier, the lung counting system was calibrated by an *in-vivo* calibration technique, which involved inhalation of ^{103}Pd-^{51}Cr [20 keV X-ray and 320 keV g-ray] labeled polystyrene aerosols by human volunteers, as part of an international intercomparison exercise. The present

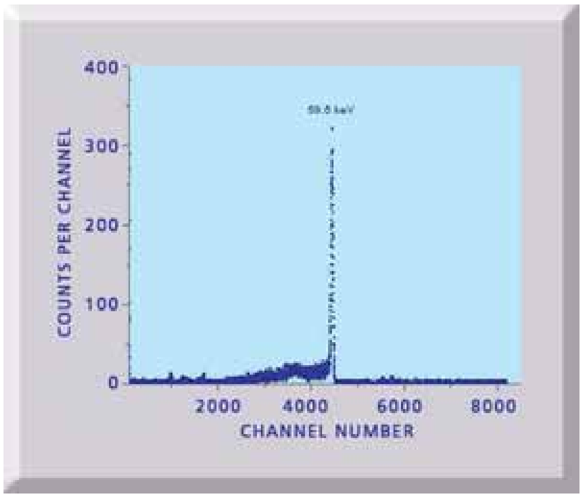


Fig. 3: Pulse height spectrum of ^{241}Am in lungs of JAERI phantom recorded with LOAX HPGe detector

calibration factors for assessment of lung burden due to actinides, are based on measurements carried out in the mid eighties using realistic thorax phantom, designed and developed by the Lawrence Livermore National Laboratory (LLNL), USA and again in the year 1997 using JAERI (Japan Atomic Energy Research Institute) phantom i.e. Reference Asian phantom. Recently, the phoswich and HPGe system have been tested again using JAERI phantom as a part of IAEA intercomparison exercise.

APPLICATION OF FISSION TRACK ANALYSIS (FTA) TECHNIQUE, FOR ESTIMATION OF INTERNAL CONTAMINATION DUE TO PLUTONIUM

In order to carry out internal contamination monitoring of workers handling plutonium, analysis of urine/ faeces is normally carried out, to determine excretion rate of plutonium. The method involves chemical separation of plutonium from the bioassay sample, followed by electro deposition and final activity quantification by alpha spectrometry. Fission Track Analysis (FTA) technique is more sensitive than the above method. Therefore, it has been standardized for measurement of trace levels of Pu in bioassay samples. In this technique, chemically separated plutonium from the sample and a Pu standard are electrodeposited on planchettes, covered with Lexan Solid State Nuclear Track Detector (SSNTD) and irradiated with thermal neutrons in the APSARA reactor of BARC. Pu in the samples undergoes fission and the resulting fission fragments produce tracks in the Lexan film. After irradiation, the Lexan films are chemically etched with 6 M NaOH at 60° C for 1 hour. The tracks thus developed are counted manually, using 400 X magnification optical microscope. The net fission tracks in the Lexan films of the sample and the standard are used, to calculate the amount of Pu in the sample. Presence of uranium in the reagents used for the chemical separation of Pu can lead to interferences in the analysis of Pu at trace level. Therefore, doubly distilled electronic grade reagents

Fig. 4: Fission track analyzer set-up

The minimum amount of Pu that can be determined by this method, using doubly distilled electronic grade reagents, is about 12 mBq/L. Further efforts are being made, to improve minimum detection limit and to automate the time consuming process of counting of fission tracks manually by using image analyzer.

are used. The contribution from background level of uranium present in the urine sample is further minimized, by carrying out separation using two stages of ion exchange separation (cation exchange separation followed by anion exchange). The decontamination factor achieved by this process is about 1×10^7. Fig. 4 shows the FTA setup and Fig. 5 shows the tracks observed with the microscope.

THORON-IN-BREATH MEASUREMENT TECHNIQUE FOR ESTIMATION OF THORIUM BODY BURDEN

Thoron (^{220}Rn) is a noble gas and it occurs in the decay series of ^{232}Th. It is possible to estimate thorium body burden of a person, by measuring the thoron content in his breath by using an ElectroStatic Chamber (ESC). The method is based on the observation, that more than 88% of decay products of thoron are positively charged ions at birth and may be collected on an electrode maintained at sufficiently high negative potential. In order to estimate thoron in breath, the person is made to inhale thoron-free air from a delay chamber and exhale into the electrostatic chamber having a collection electrode, maintained at sufficiently high negative potential. The thoron progeny atoms formed due to decay of thoron in the electrostatic chamber are collected on a removable metallic plate, kept attached

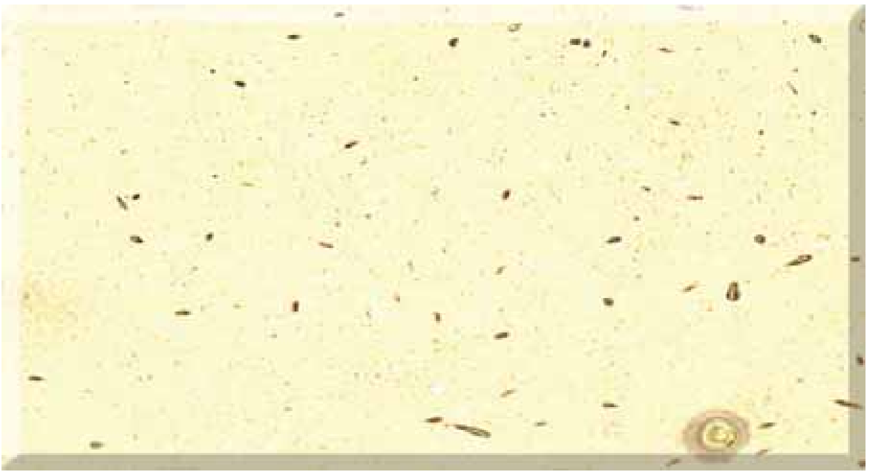


Fig. 5: Fission tracks per field (1.91×10^{-3} cm^2) observed under 400X magnification

to the electrode, which is later assayed for alpha activity using ZnS(Ag) scintillation detector. By proper calibration of the system, it is possible to correlate alpha activity collected on the metallic plate with thorium body burden. Fig. 6 shows the Thoron In Breath Measurement (TIBM) setup. The minimum detectable level of thorium in the body, for this system is about 4 Bq which is a small fraction of the ALI. A software has been developed to compute thoron in breath, thorium in the body and the resultant dose from the gross alpha counts, obtained from a PC-based alpha counting system. Recently we have started thoron-in-breath measurement on some workers from gas mantle industry, who handle thorium powder.

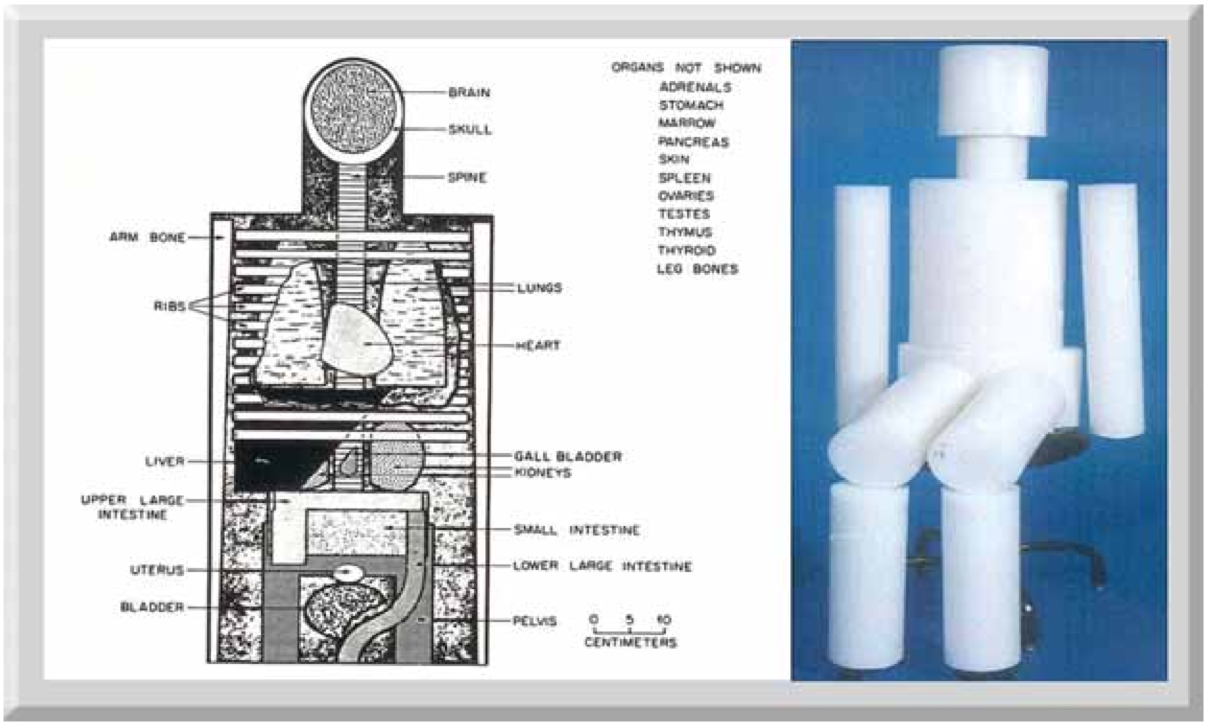
Fig. 6: A TIBM instrument is being used for monitoring of a worker due to possible contamination from thorium

THEORETICAL STUDIES IN INTERNAL DOSIMETRY

1. Monte Carlo studies

The Monte Carlo techniques have been utilized with a great deal of success, in the field of radiation protection, particularly in internal dosimetry of radionuclides. At BARC, a variety of detection systems are in operation, for estimation of internal contamination due to actinides and fission/activation products. The detection systems (Phoswich, Array of HPGe) used for assessment of lung/liver burden of LEP emitters require calibration with realistic thorax phantoms (LLNL, JAERI). The partially and wholly shielded detection systems, employed for the assessment of HEP emitters, are calibrated with tissue equivalent BOMAB phantoms. Attractive alternatives to physical phantoms are the theoretical calibration methods, involving Monte Carlo techniques in conjunction with mathematical phantoms, such as MIRD / Cristy and BOMAB (Fig. 7). An added advantage of theoretical calibration is the fact, that detection efficiencies can be calculated for any photon energy, source distribution, shape and size of the organ, detection geometry and the physique of the radiation workers.

Based on Monte Carlo photon transport techniques, a number of specialized software in FORTRAN language, have been developed in the division. In brief, the software generated different types of source distributions in the relevant organs/whole body and simulated photon transport through different types of tissue media of the mathematical phantom, considering possible interaction processes, namely photo-electric, Compton and pair-production, in proportion to their individual probabilities. A photon is traced in the relevant part of the phantom (head, neck, thorax, whole body), until it either gets completely absorbed or escapes the phantom. The programme finally simulates pulse height response and the corresponding Detection Efficiencies (DEs) of the various detection systems, employed for assessment of internal contamination of radionuclides.



(a) (b)

Fig. 7: (a) Anterior view of the principle organs in the head and the trunk of the Cristy adult phantom and (b) a physical BOMAB phantom

Theoretical studies have also been carried out, for a series of realistic mathematical phantoms, generated by scaling down the Cristy and BOMAB phantoms, to represent radiation workers of different physiques (W/H=36kg/137cm to 93kg/188cm). In addition to this, based on experimental comparison studies, lungs, liver and skull in Cristy phantom were redesigned to be more realistic and the same were incorporated into the computer programmes. The various Monte Carlo codes developed in the division are: i) 'FANTOM' for lung burdens of actinides, ii) 'FANTLIV' for liver burdens of actinides and Pm-147, iii) 'SKULL' for skull/ skeleton burdens of actinides iv) 'THYROID' for thyroidal burdens of Iodine-125,131 and, v) 'BOMAB' for whole body burdens of fission and activation products. These experimentally validated codes, have generated a variety of information not obtainable from the physical phantoms. The calibration factors determined from these codes, for various detector geometries, have been used for assessment of internal contamination, due to LEP emitters. As an illustration, the development of computer programme SKULL is described in the following paragraph.

Based on Monte Carlo photon transport technique a computer programme SKULL was developed, that generates surface sources of actinides on the skull and simulates response of a 20 cm dia phoswich detector, positioned on the top / side of the head of the Cristy phantom. The skull in the Cristy phantom consists of an ellipsoidal cranium and facial skeleton, which has a shape of elliptical cylinder. For Monte Carlo simulation of uniform surface sources of bone seeking actinides (Pu/Am) on the skull, the probability density function governing the elliptical/ ellipsoidal distributions

(F(q) / G(m, f)) were mathematically derived and Monte Carlo sampling techniques were used, to simulate the source points on the skull surfaces. A large number of histories (10^6) of these source photons, well defined in position co-ordinates, energy and direction cosines are traced, through the various media of the head of the Cristy phantom. The Monte Carlo photon transport scheme developed is illustrated as a flow chart (Fig. 8). The programme finally determines the observable Pulse Height Spectrum (PHS) and the corresponding calibration factors of the detector for different counting geometries. Fig. 9 depicts the generated PHS of a 20 cm dia. phoswich detector, positioned on the side of the head of the Cristy phantom, from uniform surface distribution of ^{241}Am source.

In addition to the several developed codes, a general purpose Monte Carlo code MCNP 4A has also been used, for calculation of several important detector

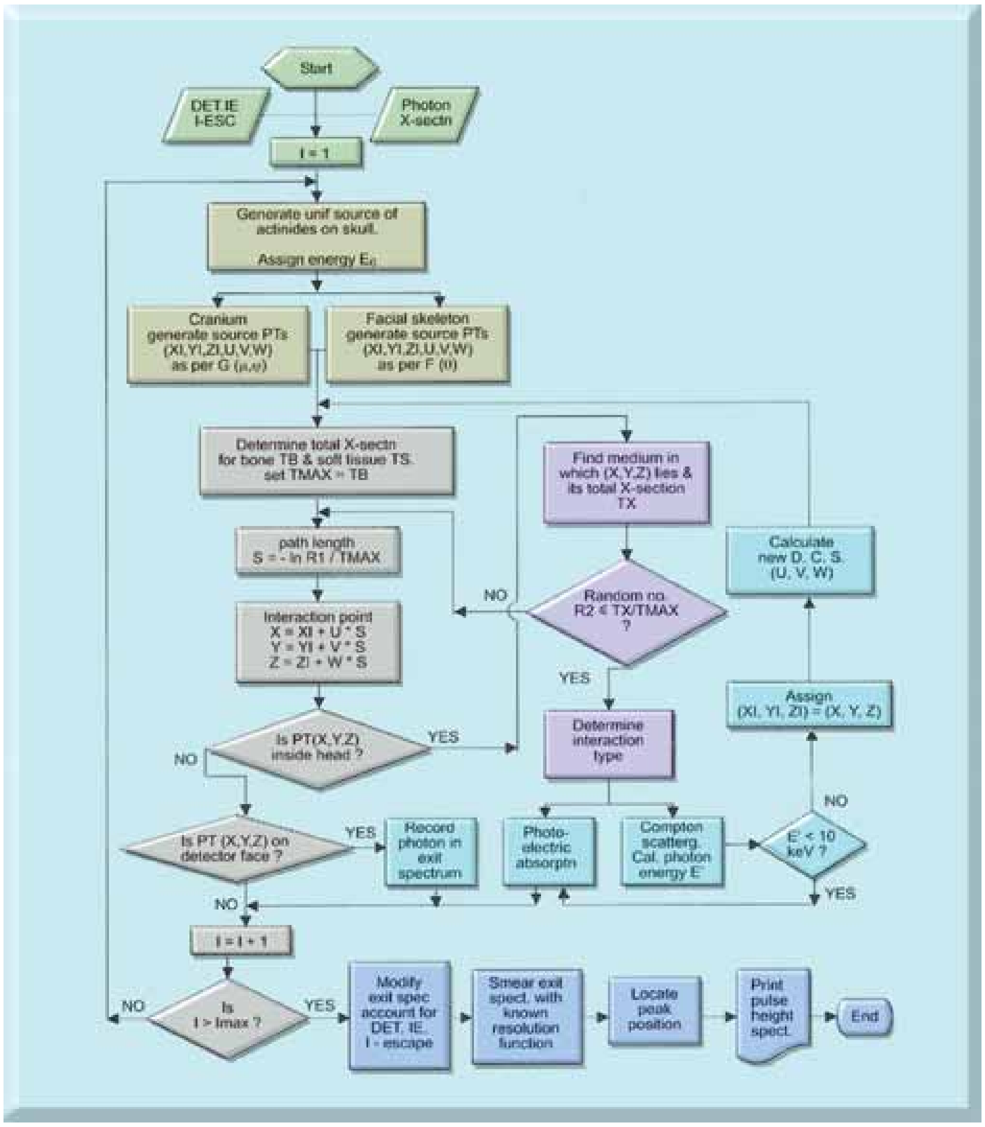


Fig. 8 : Flow chart of the computer program SKULL developed for computing the response of a phoswich detector to actinide source distributed on the skull

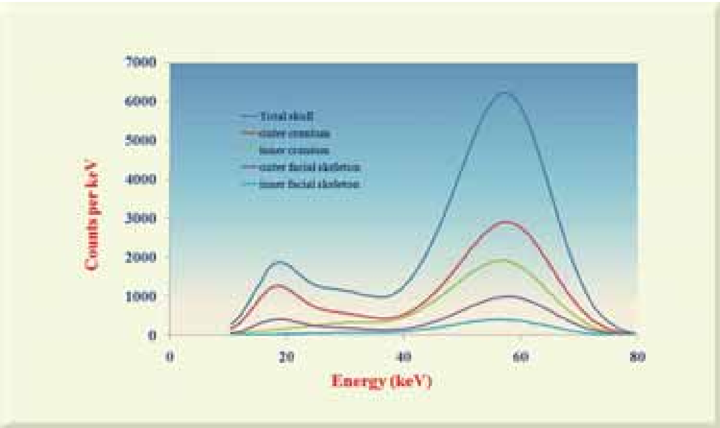


Fig. 9: Generated pulse height spectrum of a phoswich detector for uniform distribution of ^{241}Am activity on the skull of Cristy phantom

parameters such as photo fraction, intrinsic efficiency, Iodine K-shell escape probability for NaI (Tl) detectors of different sizes in addition to the calibration of *in vivo* monitoring systems of the division. The results from the Monte Carlo studies have been used, for the assessment of organ/whole body burden of several radionuclides of interest for radiation workers of different physiques, as well as for the estimation of uncertainties associated with various detection parameters such as source distribution, shape and size of the source-organ and detection geometry.

2. Internal Dose Calculations, Biokinetic Studies and Relevant Software

In the past few years, ICRP has made major revisions in it's recommendations regarding protection from ionizing radiations. It has developed a series of biokinetic and dosimetric models, for calculating radiation doses from intake of radionuclides in the body. It has also developed new Human Respiratory Tract (HRT) and Human Alimentary Tract (HAT) models for this purpose. The new models have been developed, to enable dose estimates for radiation workers as well as for the general public, including children of all age groups. These new models are considerably more complex as compared to earlier ones and as a consequence they present considerable difficulties in their implementation.

A computer programme has been developed and standardized by the division, for dose assessment and biokinetic studies of various radionuclides. The method incorporates the compartmental form of the new HRT, Gastro-Intestinal Tract (GIT) and new biokinetic model of several radionuclides of interest. HAT will be incorporated in future software. The method provides solution from the complete compartmental model and can calculate the daily urinary excretion and the amount of radioactivity in various organs at any time, for both acute as well as for chronic intake by inhalation and ingestion. The method can be used for any radionuclide, by incorporating it's biokinetic model in compartmentalized form along with it's transfer rate constants. The programme also calculates the total number of disintegrations (U_S) over any time interval in any organ and enables computation of committed effective doses. The programme has been used to evaluate the material specific clearance and absorption rates from the measured lung retention of ^{125}Sb. Using these material-specific data and default ICRP parameters, the programme enables computations of committed effective doses for different types of compounds. In addition to this, computations of Inhalation Dose Coefficients (Sv Bq^{-1}) for absorption Type S compounds of ^{125}Sb for occupational exposures (default size 5 μm AMAD aerosol) have been carried out. These values are not available from any of the ICRP publications. The results obtained with material specific data instead of default ICRP parameters, are expected to yield more realistic internal dose estimates for the radiation workers. This method has been used to solve the biokinetic models of several radiologically important elements like Pu, U, Th, Sr, Cs, I and Sb. The result obtained by solving biokinetic models, was compared with the experimentally obtained values. This was also used to find out uncertainties in ICRP biokinetic parameters.

Many software packages like LUDEP, MONDAL/MONDES, IMIE and IMBA are commercially available for internal dose evaluation. Among them the most advanced software package is Integrated Modules for Bioassay Analysis (IMBA) Professional Plus. This incorporates latest biokinetic model of various radionuclides. The division has recently procured this software. The software is having many advanced features for standard calculations and all of the ICRP default values can be selected from built in database at the touch of a button. For more detailed calculations, the user can enter individual parameter values. The IMBA has enhanced the capabilities of internal dosimetry laboratory further, since certain types of exposure scenarios can only be handled by this software. Calculation of internal dose for few case studies have been carried out using IMBA and compared with ICRP-78 methodology. The IMBA allows the user simultaneous fitting of more than one measured data types i.e. urine, faeces and whole body of radiation worker, for best estimate of intake. As a result, it gives realistic estimate of intake and committed effective dose.

IAEA Intercomparison exercise: Reference Asian-JAERI Phantom

Assessment of lung burden due to actinides such as plutonium and uranium isotopes and ^{241}Am, is based on the detection of low energy photons and x-rays emitted in their decays. These Low Energy Photons (LEP < 100 keV) suffer severe attenuation due to soft tissues and rib bones overlying the lungs. Therefore, it is necessary to calibrate the detection systems used for lung monitoring of radiation workers, using realistic phantom. The JAERI phantom is a realistic phantom representative of thorax of Reference Asian man as against LLNL phantom which is a representative of a Caucasian man. The JAERI phantom was received by the division under IAEA sponsored intercomparison exercise viz. "Intercomparison of Radiological Measurements for Monitoring Purposes – Direct Measurement of Radionuclides in Simulated Organs".

Under this exercise, various phantoms were received for intercomparison purpose viz. Knee, JAERI, BOMAB and Thyroid phantoms. Knee and JAERI phantoms are realistic phantoms simulating human knee and torso of the reference man respectively and are used, for calibrating the detection systems for the actinides such as ^{239}Pu, ^{241}Am, Nat. and Enr. U. The BOMAB and Thyroid phantoms are used for calibration of detection systems for HEP emitters such as ^{131}I, ^{137}Cs and ^{60}Co. IAEA circulated two sets of phantoms among participating laboratories and phantoms were designated as JAERI I or JAERI II depending on the number assigned to the set.

The JAERI core phantom contains a full rib cage, spine and scapula at the back side. The torso plate of this

Fig. 10: JAERI phantom with it's internal parts

Table 1: Summary of measurements carried out at BARC on JAERI phantom with various lung sets. Detection systems and counting geometries used are also given.

Sr. No.	Detection systems	Counting Geometries	Reference Asian JAERI phantom	
			Lung sets	No. of measurements
1.	Phoswich (20 cm dia. x 1.2 cm thick) detector with 0.5 mm Be window	Trombay Standard Geometry (TSG)*,Twin geometry in supine and prone position	^{238}Pu (Low)	11
			^{238}Pu (High)	11
			^{241}Am	11
			Nat. U	16
			3% Enr. U	15
2.	Phoswich (20 cm dia. x 0.3 cm thick) detector with 0.5 mm Be window	TSG, Twin geometry, supine and prone position	Same as 1.2 cm thick phoswich	
3.	Square Phoswich (10 cm x 10 cm) detector with 1 mm Be window	Four detectors array (Two phoswich over each lung), TSG, in supine, prone and lateral position	^{241}Am	58
			Nat. U	61
			3% Enr. U	50
4.	NaI(Tl) (12.7 cm dia. x 1.27 cm thick) detector with 1mm Be window	TSG, Twin, and Tilted geometry in supine, prone and lateral position	^{241}Am	73
			Nat. U	71
			3% Enr. U	73
5.	NaI(Tl) (20 cm dia x 10 cm thick) detector with 1mm thick SS window	Static & scanning geometry	^{232}Th	20
6.	An array of three LOAX HPGe detectors (7 cm dia. x 2.5 cm thick) with 0.8 mm carbon window	TSG and tilted geometry in supine and prone position	^{238}Pu (Low)	15
			^{238}Pu (High)	15
			^{241}Am	16
			Nat. U	16
			3% Enr. U	16
			^{232}Th	15

*In this geometry detector is placed in the central region of the chest, above the lungs with upper edge of the detector touching the sternum bone below the neck.

phantom is constructed of an adipose-muscle substitute mixture and contains synthetic bone and cartilage. The overlay plates of the phantom are constructed of different adipose-muscle substitute mixtures, to simulate different Chest Wall Thicknesses (CWT). The torso cavities contain lungs, heart, liver and other organs. Six lung sets were provided with the phantom, which contained natural thorium, natural uranium, uranium with 3% ^{235}U enrichment, ^{241}Am, and two ^{238}Pu sets with significantly different amount of radioactivity. The JAERI Phantom with it's internal parts is shown in Fig. 10. About 700 measurements were performed with JAERI phantom in various geometries using several detection systems viz. phoswich, LOAX HPGe and NaI(Tl). Table 1 gives a summary of these measurements.

Estimation of activity in JAERI II was carried out using calibration factors obtained from the earlier measurements carried out on JAERI I phantom during on earlier IAEA CRP. As the JAERI II phantom was not provided with the blank lung sets, normal subject background (subject having weight and height similar to the JAERI Phantom) was taken to estimate the activity. The results and other data were reported to IAEA for intercomparison.

Fig. 11a shows ^{241}Am spectrum with Phoswich (1.2 cm thick) detector for a point source kept at a distance of 10 cm from detector and Fig. 11b shows Phoswich spectrum with JAERI core phantom (CWT = 1.91 cm) with ^{241}Am lung insert. The attenuation of 18 keV peak and peak broadening because of scattering due to the chest wall thickness of 1.91 cm are observed in Fig. 11b.

IAEA / IDEAS Intercomparison Exercise

IAEA had organized various intercomparison exercises at national and international levels, for the assessment

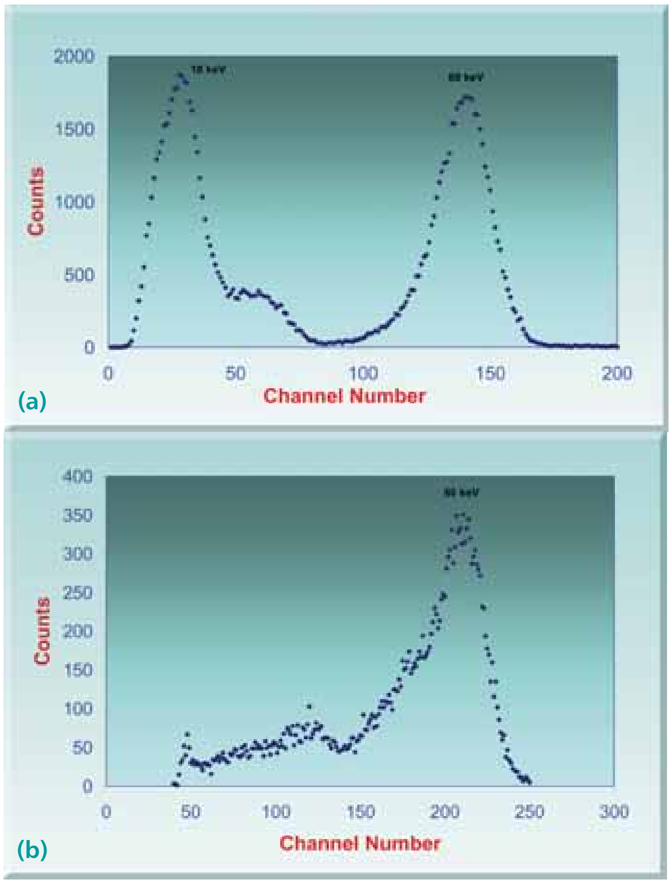


Fig. 11: Spectra of ^{241}Am with phoswich (1.2 cm thick) detector for (a) a standard point source at 10 cm from detector and (b) source distributed in the lungs of JAERI phantom.

Table 2: Our reported values of Intake and CED for various cases and the compiled results of IAEA

Case No.	Cases	Reported Results		IAEA compilation of the results	
		Intake	CED	Intake	CED (GM±GSD)
1	Acute Intake of HTO: urinary excretion data of 0 – 274 days was given. CED is estimated using direct method of dose estimation given in guidelines.	-	23.36 mSv	-	25.7 ± 1.4 mSv
2(a)	Acute inhalation of fission products ^{90}Sr and ^{137}Cs: Whole body counting data for ^{137}Cs and urinary and fecal excretion data from 0 to 634 days for ^{90}Sr were given. ^{137}Cs results.	118 kBq	0.789 mSv	103.2 kBq	0.666 ±0.1 mSv
2(b)	^{90}Sr and ^{90}Yr results	60.8 kBq	4.68 mSv	106.57 kBq	8.97 ± 6.61 mSv
3	Acute Inhalation of ^{60}Co: Whole body counting data and urinary excretion data from 10 to 1010 days were given.	404 kBq	5 mSv	396 kBq	5.2 ± 1.7 mSv
4	Repeated intake of ^{131}I: Thyroid monitoring data for 0 – 8 days has been given following repeated intake of ^{131}I	118 kBq	2.33 mSv	169.66 kBq	2.58 ± 0.17 mSv
5	Acute Intake of Enr. Uranium: Lung monitoring data and urinary excretion data were given.	3.368 kBq	23 mSv	9.719 kBq	39 ± 33 mSv
6(a)	Single intake of Pu isotopes and ^{241}Am: ^{241}Am chest, lung, liver, bone measurement data & urinary and fecal excretion data were given. ^{241}Am results	4.59 kBq	34.7 mSv	4.3 kBq	69.5 ± 62.2 mSv
6(b)	Single intake of Pu isotopes and ^{241}Am: ^{239}Pu urinary and fecal excretion data were given. ^{239}Pu results	13.8 kBq	114 mSv	14.2 kBq	155 ± 78 mSv

of internal dose, due to intakes of radionuclides. These exercises revealed significant differences in the approaches, methods and assumptions used and consequently in the results obtained by participating laboratories. This led to the development of 'General guidelines for the estimation of committed dose from incorporation of monitoring data' by IDEAS project (A European Union project). The guidelines provide well defined procedures to obtain best estimate of dose from the available data, depending upon the expected level of exposure and the complexity of the case.

For harmonizing the methods of assessing the committed effective dose to workers after an intake of radionuclides using these guidelines, a joint IDEAS/IAEA intercomparison exercise viz. "Intercomparison exercise on assessment of occupational exposure" was organized. The division has participated in this exercise, which consisted of six cases covering wide and complex exposure scenarios. The cases given were (i) acute intake of HTO, (ii) acute inhalation of fission products ^{137}Cs and ^{90}Sr, (iii) acute inhalation of ^{60}Co, (iv) chronic intake of ^{131}I, (v) enriched uranium intake and (vi) intake of Pu and Am. The cases were solved using LUDEP, MONDAL/MONDES and IMBA dose evaluation software and results were submitted to IAEA. Eighty one participants from forty two countries submitted the results to IAEA. Out of these, only thirty five participants had solved all the cases. Our laboratory is one of them. IAEA statistically analyzed the results reported by the participating laboratories, using Log-Normal distribution for Geometric Mean (GM) and Geometric Standard Deviation (GSD) and for better graphical representation of the data. Our results were found to be in good agreement with the IAEA results. Table 2 shows the Intakes and CED values estimated by our laboratory and the results compiled by IAEA for the six cases given in the intercomparison exercise. This table includes only a brief description of the exposure cases. The CED values given by IAEA are the GM of all the values reported by the participating laboratories. These values are given in this table along with their GSD.

The detailed results of the participating laboratories for Case No. 6 (Mixed exposure to two important radionuclides ^{239}Pu and ^{241}Am) as reported by IAEA are given in Fig. 12 (a & b). The results of our laboratory are shown by a red arrow. It is seen that the results have excellent agreement with mean values.

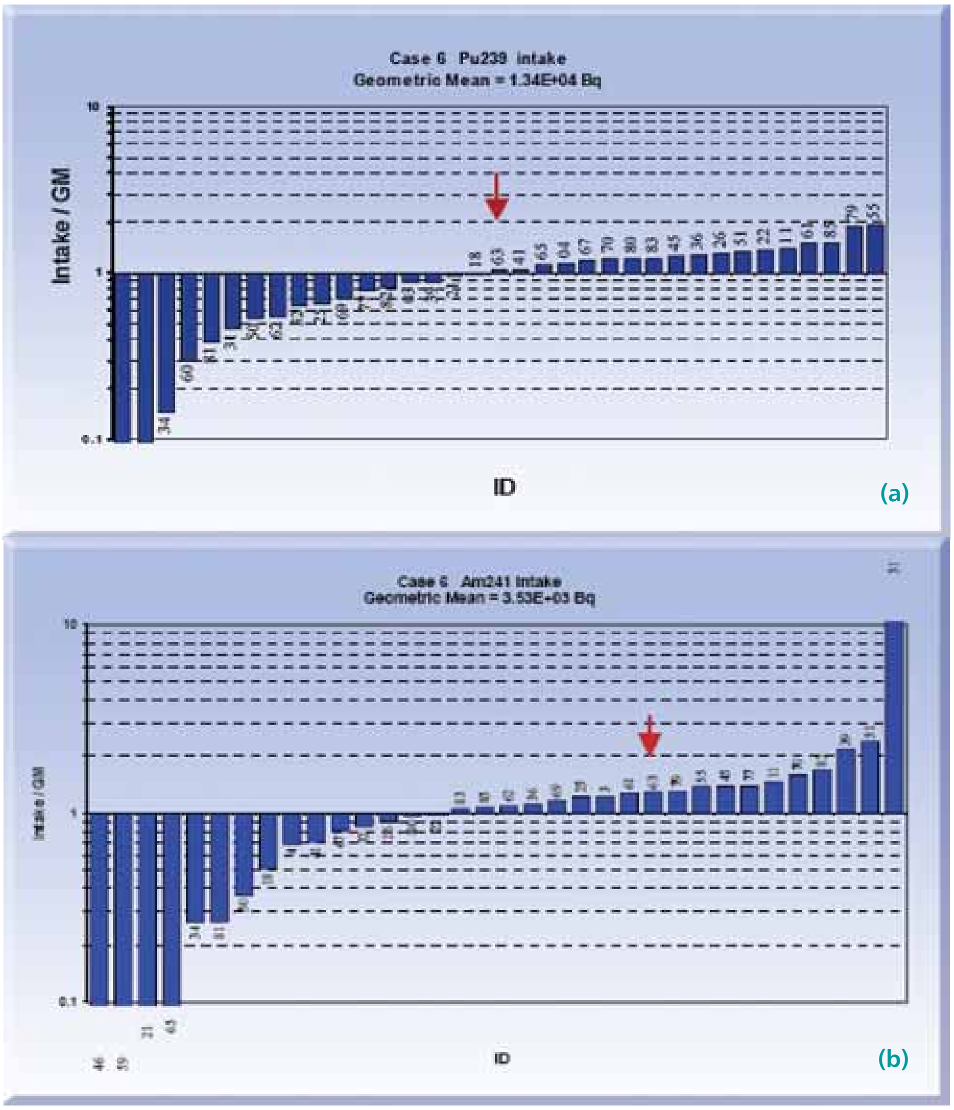


Fig. 12: Results of the individual participants as reported by IAEA for (a) ^{239}Pu and (b) ^{241}Am Results of our laboratory are shown by red arrow

Intercomparison of shadow shield bed whole body monitors

Shadow shield bed Whole Body Counters (WBC) using a NaI(Tl) detector have been installed at various DAE units like BARC Trombay, Environment Survey Laboratories attached to Nuclear Power Plants (NPP), Health Physics Laboratory and also at some of the other facilities of DAE. The WBCs are used to estimate internal contamination in workers due to high energy photon emitters such as ^{60}Co, ^{131}I, ^{137}Cs etc. The division initiated an intercomparison exercise to compare the response of WBCs at BARC, Trombay, ESLs of NPP and Health Physics Laboratory Tarapur. The work is nearing completion.

Acknowledgements

The authors are thankful to Mr. S. H. Shirke and Mr. D. Toppo for their technical support.

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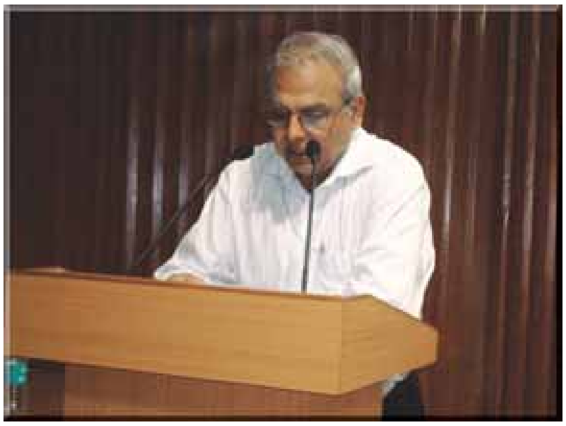
RADON-2008: DAE-BRNS THEME MEETING : A REPORT

The Health, Safety and Environment Group (HS&EG) organized a DAE-BRNS sponsored theme meeting entitled: "RADON-2008: Advances in the methods of assessment of exposure due to radon, thoron and their decay products" during March 11-13, 2008, in CT&CRS auditorium, Anushaktinagar, Mumbai. The objective of the meeting was to enhance and share the knowledge on advanced measurement techniques and theoretical models for assessing radon, thoron and progeny exposures. This was attended by 44 non-DAE participants from 25 national universities and institutions and 30 DAE participants nominated from different divisions in BARC.

The meeting was inaugurated by Dr. S. Banerjee, Director, Bhabha Atomic Research Centre, Mumbai. Mr. H. S. Kushwaha, Director HS&EG; Prof. S. Tokonami, National Institute of Radiological Sciences (NIRS), Japan and Dr. K.S. V. Nambi, Former Head EAD were also present on this occasion. Dr. Banerjee emphasized the need for multi-parametric research and the importance of theoretical research along with the coordinated experiments. Dr. Nambi stressed on the fact, that the new developments in the Environmental Assessment Division are a major step forward which need to be communicated and shared with other Indian researchers, working in the field.

Prof. Tokonami in his key-note address, emphasized the need to measure thoron, which has always been underestimated and as a consequence of which sparse epidemiological data for thoron is available. He discussed the radon/thoron discriminator detector (RADUET) and calibration chamber at NIRS, Japan and CR-39 based deposition monitors and the related epidemiological studies carried out by their group. Dr. Y.S. Mayya, Head AMSS and convener RADON-2008, explained the need for an integrated approach (covering both theoretical modeling and experiments) towards assessment of radon, thoron and their progeny. He defined the self-compensating theory, stressing the need for deposition based sensors which can be efficiently used to mimic lung deposition.

The lectures delivered in the technical sessions were compiled into a proceedings volume. The following topics were discussed.



Mr. H. S. Kushwaha, Director HS&E Group giving the Welcome address and Dr. S. Banerjee, Director, BARC presenting the Inaugural address

Dr. S. Banerjee, Director, BARC, Prof. S. Tokonami, NIRS, Japan and Dr. K.S.V. Nambi, Former Head, EAD, BARC at the inaugural function

Dr. M. Seshadri, RB&HSD, BARC discussed the biological effects of radiation exposures and the complexities in estimation of response at low doses.

Dr. P. M. B. Pillai, EAD, BARC, elaborated on thoron and it's progeny exposures at the front-end of Nuclear Fuel Cycle activities with special reference to radioactive minerals, thorium and rare earths processing.

Mr. B. K. Sahoo, EAD, mentioned about the theory of radon emanation and methods of source term estimation by the newly developed flux measurement techniques.

Dr. B. K. Sapra, EAD, discussed the dynamics of progeny-aerosol interaction and the methods estimation of activity size distribution of the aerosol attached radon/thoron progeny.

Dr. Rosaline Mishra, EAD, discussed the recently developed direct progeny sensors based on monitoring of deposition velocity.

Dr. K. P. Eappen, EAD, elaborated on the Radon monitoring and real-time continuous radon/thoron monitor for environmental applications.

Dr. G. K. Srivastava, EAD, discussed the measurement of radon and daughter products in U-mines and environment.

Dr. I. S. Singh, IDD, gave a detailed depiction on the current status of lung dosimetry.

Dr. R. C. Ramola, HNB, Garhwal University discussed the studies on prediction of earthquakes based on radon/thoron measurements.

Dr. T. V. Ramachandran, EAD, presented the results of the last country-wide CRP and gave a brief picture on the status of radon-thoron distribution in India.

Other speakers from various national institutes, presented the status of radon and thoron in different regions of India, facilities and advances in radon, thoron and decay product monitoring at other national

Session in progress during RADON-2008

departments, geology of radon and related tectonics, influence of trace element geochemistry, exhalation rate from various sources, gamma levels and the exposure levels measured in high background radiation areas.

On the 2nd day of the meeting, hands-on demonstration of the instruments developed in Environmental Assessment Division was held. The working principle and operation of the various samplers and instruments such as Progeny Deposition monitors (DTPS and DRPS), Unattached/Attached fraction Progeny sampler, Real time Radon and thoron monitor, dynamic Radon-Thoron flux monitor and Particle Aerodynamic Size Separators (PASS) was demonstrated.

A brainstorming interactive session was also held, to initiate a multi-parametric study programme to validate the deposition dosimetry technique in different environments, using new instruments developed in the Environmental Assessment Division, through a BRNS sponsored, national radon project involving Indian Universities. Dr. Y.S. Mayya presented the proposal giving the need for progeny measurements and the importance of parametric measurements. Suggestions on this project were invited from Mr. Markandeya, Head, Planning and Co-ordination Division, BARC, Dr. K.S.V. Nambi (Former Head, EAD) and other participants for evolving a target oriented project of about 2 years duration, involving about 10 institutions.

The concluding session of the theme meeting was held on 13th March 2008. Dr. D. N. Sharma, Head, Radiation Safety Systems Division (RSSD); Dr. Pendharkar, Head, Internal Dosimetry Division (IDD) and Dr. K.S.V. Nambi, Former Head, EAD, graced the occasion.

FIFTH SUPERVISORY TRAINING PROGRAMME ON RADIOACTIVE WASTE MANAGEMENT : A REPORT

The Supervisory Training Programme on Radioactive Waste Management was designed and formulated for the supervisors, who are associated in waste generation and engaged in waste management and have not received any formal training. Four of these training programmes were conducted at BARC, Tarapur. The Fifth Supervisory Training Programme of this series was conducted at the Centralized Waste Management Facility (CWMF), Kalpakkam from Oct. 22 - Nov.2, 2007. This training programme covered various aspects of radioactive waste management, radiation protection and industrial safety.

A total of 52 participants belonging to waste management plants/facilities/ projects from Trombay, Tarapur and Kalpakkam attended the course. The supervisors from PP, KARP, PREFRE, MAPS, FBTR and IGCAR also attended the programme. The training programme was carried out through classroom lectures, demonstrations and visits to FBTR, KARP, MAPS and CWMF.

During the inaugural programme, on October 22, 2007, Dr. P. K. Sinha, Plant Superintendent, CWMF, welcomed the gathering. Mr. R.G. Yeotikar,

Mr. R.G.Yeotikar, Officer-in-Charge, Training, NRG, introducing the syllabus for the training programme during the inaugural function. Others on the dais from left to right are Mr. Kanwar Raj, Head, WMD, Mr. K.V. Mahudeeswaran. PD, NRGP(K) and Dr. P. K. Sinha, PS, CWMF(K)

A view of the group of participants and the dignitaries during the inaugural function

Officer-in-Charge, Training and organizer of this programme, introduced the syllabus of the programme and explained the importance of the selected subjects. Mr. Kanwar Raj, Head, Waste Management Division, appreciated the efforts in organizing the training programme and emphasized how the training is essential and useful for updating knowledge in various aspects of radioactive waste management. He presented an invited talk on the philosophy of radioactive waste management and explained about the practices being followed, to achieve the objective of minimization of the impact on environment and on the future generation. He also emphasized the need to reduce the generation of waste and the necessity to reuse and recycle. A technical talk was also delivered by Mr. K.V. Mahudeeswaran, Project Director, NRGP, Kalpakkam, on the WIP, Kalpakkam.

Faculty members who were expert in their respective fields, were invited to cover varied topics viz. radioactive waste management, industrial and fire safety, radiation monitoring, health physics, first aid, ventilation aspects, off-gas cleaning, special techniques for generating wealth from waste, remote handling, database generation, future projects, instrumentation, process flow-sheet of WIP, Kalpakkam, minimization of waste, fast reactor technology, radiochemistry programme, etc.

The Valedictory function of this training programme was held on Nov. 02, 2007 and was presided over by Mr. P.V. Ramalingam, Director, ROMG, IGCAR. The other guest of honour was Mr. P.K. Dey, Head, FRD, BARC. During this valedictory function, a feedback session was arranged for participants from all the sites. Mr. R. G. Yeotikar, Officer-in-Charge, Training, responded to this feedback. Dr. (Ms.) S.S.Raj, Local Coordinator, gave a vote of thanks after the valedictory function.

IAEA/RCA REGIONAL TRAINING COURSE ON "APPLICATIONS OF AGREED NUCLEAR TECHNIQUES TO MEASUREMENT OF NUCLEAR CONTAMINANTS IN MARINE SYSTEMS"

The Environmental Assessment Division organized the IAEA / RCA Regional Training course on "Applications of Agreed Nuclear Techniques to Measurement of Nuclear Contaminants in Marine Systems" under the IAEA / RCA project, "Establishing a Benchmark for Assessing the Radiological Impact of Nuclear Power Activities on the Marine Environment in the Asia Pacific Region" RAS/7/016, from May 27 to June 06, 2008 in Mumbai, India.

IAEA initiated the RCA project to develop and strengthen coordinated regional marine radioactivity monitoring programmes, designed to yield results that are useful, verifiable and transferable (i.e. harmonized) to meet regional objectives. The main objective of the project is to update and sustainably maintain the existing regional database known as Asia Pacific Marine Radioactivity Database (ASPAMARD) as part of Global Marine Radioactivity

Group photograph of participants, experts from IAEA and scientists from BARC

Database (GLOMARD). This is an ongoing repository for new data, generated from monitoring programmes, to enhance the utility of this regional resource, for analyzing trends and understanding the fate and behaviour of key radionuclides in the marine environment.

The course provided specific training to nineteen participants from different Member States (MS) from Asia Pacific Region in theoretical background, practical applications and interpretation of the state of-the-art radioanalytical methodologies, for measurements and sampling of radionuclides in marine environmental samples, i.e. sediments, waters and biota. During the training course, a series of lectures, were devoted to theoretical aspects of various nuclear techniques for analysis and interpretation of data. Field experiments were conducted at Alibaug, for practical demonstration of *in situ* preconcentration methods for fallout radionuclides. Laboratory exercises and demonstrations of various nuclear techniques were conducted at laboratories located at BARC Hospital. Each participant was provided with printed guidelines, lectures notes and presentations on CD ROM. Participants were assessed for their acquired knowledge on the last day of the training course. Participants achieved practical experience in collection of marine environmental samples and application of radioanalytical methodologies, for measurement of radionuclides in marine environmental samples.

The laboratory facilities of EAD and HPD located at the BARC Hospital Complex, Anushaktinagar were utilized during the training. Training course was supported by six experts from the department and three experts from IAEA. Mr. V.D. Puranik, Head, Environmental Assessment Division, BARC was the Course Director and Dr S.K. Jha, Environmental Assessment Division, BARC was Coordinator for the Training Course.

Forthcoming Symposium

National Laser Symposium (NLS-08)

The above symposium, the eighth in the series will be held at the Laser Science and Technology Centre (LASTEC), New Delhi, from Jan. 7-10, 2009. The focal theme of the symposium would be " High power, High energy lasers" and the scientific programme would include invited and contributed presentations, Ph.D thesis presentations and oral and poster presentations. The Indian Laser Association has arranged a short tutorial course on the 5th & 6th January, 2009. it has also instituted prizes for Best Paper & Best Poster presentations. Researchers are invited to send papers on the following topics: "Physics and Technology of Lasers; Lasers in Nuclear Science & Technology; Laser Materials, Devices & Components; Quantum Optics; Ultra-fast Lasers & Applications; Nonlinear Optics; Lasers in Material Science; Tunable Lasers & Applications; Laser Plasma Interaction; Lasers in industry, Defence and space; Lasers in Spectroscopy; Lasers in Chemistry, Biology & Medicine; Laser-Based Instrumentation."

Important Dates

Receipt of manuscript : Sep. 15, 2008
Intimation of acceptance : Oct. 31, 2008
Submission of Registration : Nov. 03, 2008

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भा.प.अ. केंद्र के वैज्ञानिकों को सम्मान

BARC SCIENTISTS HONOURED

श्रीमती सुलग्ना डे, एस.के. मुशरफ अली, एम.आर.के. शिनोइ, संदीप के. घोष एवं दिलीप के. माइती द्वारा लिखित "कन्फरमेशनल इफेक्ट ऑन दि प्रफरंशल बाईंडिग ऑफ अल्कली मेटल विथ क्राउन ईथर, ए मोलिक्यूलर लेवल इनवेस्टिगेशन" नामक शोध-पत्र को देहली विश्वविद्यालय में आयोजित 12-14 मार्च 2008 के दौरान एसईएसटीईसी-2008 में सर्वश्रेष्ठ शोध-पत्र पुरस्कार प्रदान किया गया। यह शोध-पत्र श्रीमती सुलग्ना डे के द्वारा प्रस्तुत किया गया।

A paper entitled "Conformational effect on the preferential binding of alkali metal cation with crown ether: a molecular level investigation" by Sulagna De, S.K. Musharaf Ali, M.R.K. Shenoi, Sandip K. Ghosh and Dilip K. Maity was given the Best Paper Award at SESTEC-2008, held at University of Delhi, Delhi during March 12-14, 2008. The paper was presented by Ms. Sulagna De.

Ms. Sulagna De

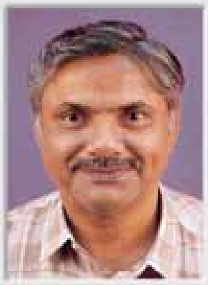
श्रीमती सुलग्ना डे, 49 वें बैच की रसायनिकी प्रशिक्षणार्थी ने वर्ष 2006 में भाभा परमाणु अनुसंधान केंद्र के रसायनिकी इंजीनियरिंग प्रभाग में सदस्यता ली। इनकी अनुसंधान रुचि के क्षेत्र में डेवलोप्मेंट फॉर दि सेपरेशन ऑफ मेटल ऑयन आइसोटोपस बेसड ऑन सॉलवंट एक्सट्रेक्शन एक्सपेरिमेंट यूजिग मेक्रो साइक्लिक लिजन्ड एन्ड आइसोटोप अलगाव प्रणाली समेत डेवलोप्मेंट ऑफ मोलिक्यूलर मॉडलिंग फॉर फंडमन्टल अंडरस्टेंडिग ऑफ मेटल-सॉलवन्ट / एक्सट्रेक्टंट इंटरेक्शन इन ऑर्डर टु स्क्रीन / डिजाइन स्यूटेबल लिजंड फॉर मेटल कैटामन एक्सट्रेक्शन भी हैं।

Ms. Sulagna De, a 49th batch Chemistry trainee joined the Chemical Engineering Division, BARC in 2006. Her research interest includes process development for the separation of metal ion isotopes, based on solvent extraction experiment, using macrocyclic ligand and development of molecular modeling for fundamental understanding of metal-solvent/ extractant interaction, in order to screen/design a suitable ligand for metal cation extraction including isotope separation processes.

Dr. S.K. Musharaf Ali

डॉ. एस.के. मुशरफ अली, 40वें बैच के रसायनिकी प्रशिक्षणार्थी ने वर्ष 1997 में भाभा परमाणु अनुसंधान केंद्र के रसायनिकी इंजीनियरिंग प्रभाग में सदस्यता ली। इनकी अनुसंधान रुचि के क्षेत्र में इलेक्ट्रोकेमिकल प्लाँट ओपरेशन, एक्सपेरिमेंटल लेबोरेटरी स्केल्ड प्रोसेस डेवलप्मेंट फॉर आइसोटोप सेपरेशन एवं कंप्यूटर एडिड मोलिक्यूलर मॉडलिंग बेसड नॉवल लिजंड डिजाइन फॉर सिलेक्टिव मेटल आयन / एक्सट्रेक्शन एन्ड थिरियोटिक्ल स्टडी ऑफ ट्रान्सपोर्ट फिनोमिना इन फल्यूइड एन्ड फल्यूइड मिक्सचर्स आदि शामिल हैं।

Dr. S.K. Musharaf Ali joined the Chemical Engineering Division, BARC in 1997 after passing from the 40th Batch Training School in Chemistry discipline. His research interest includes electrochemical plant operation, experimental laboratory scaled process development for isotope separation and computer aided molecular modeling based on novel ligand design for selective metal ion extraction and theoretical study of transport phenomena in fluid and fluid mixtures.



Mr. M.R.K. Shenoi

श्री. एम.आर.के. शिनोइ, 14 वें बैच के रसायनिकी प्रशिक्षणार्थी ने वर्ष 1971 में भाभा परमाणु अनुसंधान केंद्र के रसायनिकी इंजीनियरिंग प्रभाग में सदस्यता ली। इनकी अनुसंधान रुचि के क्षेत्र में फ्यूजड साल्ट इलेक्ट्रोलिसिज प्लाँट फॉर लाइट मेटल प्रोडक्शन, प्रोसेस डेवलोप्मेंट फॉर सेपरेशन ऑफ मेटल आयन एन्ड आइसोटोप इन लेबोरेटरी स्केल एन्ड मोलिक्यूलर मॉडलिंग बेसड नॉवल लिजंड डिजाइन आदि शामिल हैं इस समय ये रसायनिकी इंजीनियरिंग प्रभाग के स्टेबल आइसोटोप अनुभाग के अध्यक्ष हैं।

Mr. M.R.K. Shenoi joined the Chemical Engineering Division, BARC in 1971 after passing from the 14th Batch Training School in Chemistry discipline. His research interest includes setting up and operation of fused salt electrolysis plant for light metal production, process development for separation of metal ion and isotopes in laboratory scale and molecular modeling based ligand design. Presently he is heading the Stable Isotope Section of Chemical Engineering Division.

Dr. D.K. Maity

डॉ. दिलीप के. माइती ने भाभा परमाणु अनुसंधान केंद्र प्रशिक्षण विद्यालय के 33वें बैच से स्नातकता प्राप्त करने के पश्चात् वर्ष 1990 में भाभा परमाणु अनुसंधान केंद्र में सदस्यता ली। रसायनिकी प्रतिक्रिया प्रणाली विश्लेशण पर इनका अनुसंधान कार्य था तथा वर्ष 1995 में जादवपुर विश्वविद्यालय, कोलकाता से इन्होंने रसायन-विज्ञान में पीएच.डी की डिग्री प्राप्त की इन्होंने 1998-2000 के दौरान हेनरी ऐरिंग सेंटर फॉर थियोराटिक्ल केमिस्ट्री, यूनिवर्सिटी ऑफ उताह, साल्ट लेक सिटी, यूएसए में स्नातक की हेसियत से काम किया आपने विश्वसनीय बलगति विज्ञान जैसे विशेष गैस की भविष्यवाणी हेतु संक्रमण अवस्था सिद्धांत के परिवर्तन पर काम किया हैं।

Dr. Dilip K. Maity joined BARC in 1990 after graduating from the 33rd batch of BARC Training School. His doctoral work was on chemical reaction path analysis and he received his Ph.D. degree in Chemistry from Jadavpur University, Kolkata in 1995. He worked as a post doctoral fellow at Henry Eyring Center for Theoretical Chemistry, University of Utah, Salt Lake City, USA during 1998-2000. He worked on variational transition state theory to predict reliable gas phase kinetics.

श्रीमती रच-ा अग्रवाल, माइज्ल मेलजर एवं डॉ. जे. ज़े. साइ-िस -ो -ावंबर 26-28, 2007 ज़े दौरा-ा दिल्ली में आयोजित माइक्रोसज्ोपी ए-ड एलाइड साइ-िसज ज्ी राष्ट्रीय सभा में प्रस्तुत ज्ंपरेटिव अ-ािलिसिज ऑफ डिफर-ट मेथड्स ऑफ फिक्जेश-ा ऑफ यू-िसेल्यूलर स्य-ाबेज्ओरिया फॉर ट्रा-समिश-ा इलेक्ट्रॉ-ा माइक्रोसज्ोपी -ामज शोध-पत्र हेतु बेस्ट पोस्टर अवार्ड प्राप्त ज्यिा।

Ms. Rachna Agarwal, Mr. Michael Melzer and Dr. Ms. J.K. Sainis won the Best Poster Award for their paper "Comparative Analysis of Different Methods of Fixation of Unicellular Cyanobacteria for Transmission Electron Microscopy". This paper was presented at the National Conference for Microscopy and Allied Sciences, held at New Delhi between Nov. 26-28, 2007.

Ms. Rachna Agarwal

श्रीमती रच-ा अग्रवाल -ो ओसीईएस ज़े 47 वें बैच ज़े पश्चात मोलिक्यूलर बयोलोजी प्रभाज ज्ी सदस्यता ली। इ-ज्ी अ-ुसंधा-ा रुचि में स्टडीज ऑ-ा मॉलिक्यूलर आरज्ीटेक्चर ए-ड बयोजी-िसिज ऑफ फोटोसिंथेटिज एपरटस ए-ड इफेक्टस ऑफ आयो-ाइजिंज रेडियेश-ा ऑ-ा फोटोसि-िथसिज इ-ा यू-िसेल्यूलर स्या-ोबेक्टीरिया शामिल हैं।

Ms. Rachna Agarwal joined the Molecular Biology Divn. from the 47th batch of OCES. Her research interest include: Studies on molecular architecture and biogenesis of photosynthetic apparatus and effects of ionizing radiation on photosynthesis in unicellular cyanobacteria.

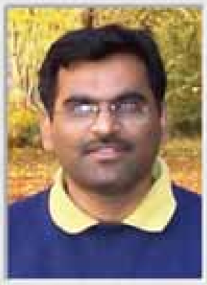
Dr. Ms. J.K. Sainis

डॉ. श्रीमती जे. के. साइनिस इस समय प्लाँट बयोकेमिस्ट्री अनुभाग, मॉलिक्यूलर बयोलोजी प्रभाग की अध्यक्ष हैं इनकी अनुसंधान क्षेत्रों में एनजाइम सुपरस्ट्रक्चरस ऑफ फोटोसिन्थिसिज, डीएनए रिपेयर एवं रिकोम्बिनेशन प्रोसेसिज, क्रोमेटिन रिमोडलिंग, कंप्यूटर विजन टेक्नॉलोजीज इन बयोलोजी, आर्टिफिशल फोटोसिन्थेसिज एन्ड स्ट्रस रेसपोन्सिस टु फोटोसिन्थेसिज इन यूनिसेल्यूलर ऑरगेनिजम्ज आदि हैं।

Dr. Ms. J.K. Sainis is currently Head, Plant Biochemistry Section, Molecular Biology Divn. Her areas of research are Enzyme superstructures of photosynthesis, DNA repair and recombination processes, Chromatin remodeling, Computer vision technologies in Biology, Artificial photosynthesis and stress responses of photosynthesis unicellular organisms etc.

श्री. सी. रजनी कान्त एवं डॉ. जे.के. साइनिस ने दिसंबर 5-7, 2007 के दौरान मुंबई में डीएई / बीआरएनएस के द्वारा आयोजित, लाइफ साइन्सिस सिंपोज़ियम में शोध -पत्र की प्रस्तुति हेतु बेस्ट पोस्टर पुरस्कार प्राप्त किया। इस शोध - पत्र का शीर्षक "अइसालेशन एन्ड फंकशनल करेक्टरैज़ेशन ऑफ ओएसआरएडी 51, ए रिकोंबिनेज़ फ्राम राइस" हैं।

Mr. C. Rajani Kant and Dr. J.K. Sainis won the Best Poster Award for their paper, presented at the Life Sciences Symposium (LSS-2007), organized by DAE/BRNS at Mumbai, during Dec. 5-7, 2007. The title of the paper is "Isolation and functional characterization of OsRad51, a recombinase from rice."



Mr. C. Rajani Kant

श्री. सी. रजनी कान्त उसमानिया यूनिवर्सिटी, हैदराबाद से बयोकेमिस्ट्री के एक स्नातक हैं। इन्होंने ओसीईएस के 44वें बैच से जैव आण्विक प्रभाग में सदस्यता ली। तब से ये धान से डीएनए पुनर्योजन के अलगाव, क्लोन, एवं जीव रसायन के चरित्रांकण पर काम कर रहें हैं। डॉ. जे.के. साइनिस के मार्गदर्शन में इन्होंने धान से डीएनए पुनर्योजन से दो विशेष ओएसडीएमसीआइ एवं ओएसआरएडी 51 का चरित्रांकन किया।

Mr. C. Rajani Kant is a postgraduate in Biochemistry from Osmania University, Hyderabad. He joined the Molecular Biology Divn., from the 44th OCES batch. Since then, he has been working on the isolation, cloning and biochemical characterization of DNA recombinases from rice. Under the guidance of Dr. Ms. J.K. Sainis, he has characterized two important DNA recombinase OsDmc1 and OsRad51 from rice.

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