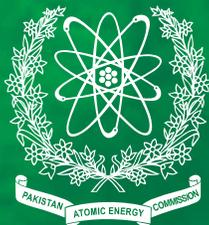


PAKISTAN

PARTNERING WITH IAEA

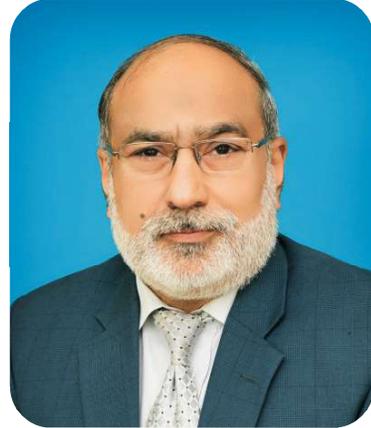
FOR STRENGTHENING SOUTH-SOUTH COOPERATION



PAKISTAN ATOMIC ENERGY COMMISSION

FOREWORD by Chairman PAEC

Pakistan being one of the founding members of the IAEA enjoys longstanding and mutually beneficial collaboration with the Agency on peaceful uses of nuclear science and technology. Pakistan attaches great importance to the IAEA's Technical Cooperation Program (TCP) that serves as the main vehicle, enabling the Agency to fulfill its primary statutory function, namely the promotion, use, and application of nuclear technology for socio-economic progress in developing Member States.



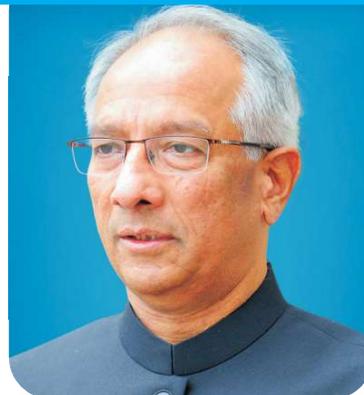
Over the years, Pakistan has been a major beneficiary of the IAEA Technical Cooperation Programme. IAEA has played a significant role in capacity building of our human resource through TC Programme. Pakistan has aligned its TC Programme with the IAEA's Medium-Term Strategy by designing and implementing Comprehensive TC Projects to achieve substantial outputs leading to sustainable development. The partnership established through the IAEA TC Programme has contributed to advancement at our institutes in diverse fields such as food & agriculture, human health, nuclear power development, water resource management, industry and education.

Pakistan-IAEA TC partnership works two ways. On the one end, it has strengthened our national capacity through the support of the IAEA while on the other end; Pakistan has extended its capabilities to support other Member States by offering expert services and hosting fellowships, scientific visits and training courses/workshops in Pakistan under the auspices of the IAEA. Recognizing the capabilities and infrastructure available in the field of applications of nuclear science and technology in Pakistan, the IAEA has designated four of our institutes as its Collaborating Centers.

Pakistan has also signed two Practical Arrangements (PAs) with the IAEA. We offer our facilities and capabilities for the training of other Member States under the auspices of the IAEA leading to strengthen South-South cooperation. The objective of this publication is to introduce the audience about the extent of expertise & facilities developed in Pakistan in cooperation with the IAEA and which are available for the benefit of other Member States. Joining hands with the IAEA to promote the applications of nuclear science and technology around the globe is another objective. I hope this publication will not only highlight the importance of continuing and enhancing Pakistan's partnership with the Agency but will also serve the objective of strengthening South-South Cooperation.

(Dr. Raja Ali Raza Anwar)

It was sixty-five years ago that Pakistan realized the enormous potential of nuclear science & technology for sustainable socio-economic development. Pakistan's first small step towards actualizing this potential was the establishment of a nuclear medical centre in 1962. From this humble beginning, Pakistan has gone on to harness nuclear science and technology in diverse areas such as food production, cash crops, animal husbandry, industry, human health, nuclear power, water resources management and environmental protection.



Today, Pakistan has a highly developed and multifaceted civilian nuclear programme, undergirded by an effective and elaborate institutional and regulatory infrastructure, which is contributing to the nation's socio-economic development. Pakistan's close collaboration with the International Atomic Energy Agency (IAEA), of which it is a founding member, played a pivotal role in the making of this success story. Pakistan and the IAEA have developed a very productive and mutually beneficial relationship spanning over decades.

Many Pakistani experts have served in the IAEA Secretariat and also as members of the Agency's review and advisory missions to other Member States. Pakistan also supports the flagship initiatives of the Director General IAEA including the Zoonotic Disease Integrated Action (ZODIAC) project, Rays of Hope, Marie Sklowdoska Curie Fellowship Programme, NUTEC Plastics and ReNuAL through extra-budgetary and in-kind contributions.

Pakistan has always prided itself on its commitment to promoting the common interests of developing countries at the international fora. At the IAEA, this commitment finds reflection in Pakistan's strong support to the Agency's role in promoting peaceful uses of nuclear technology and applications, in particular through the Technical Cooperation Programme. Going a step further and as a practical manifestation of this commitment, Pakistan is ready to share its expertise and experience in the peaceful uses of nuclear technology with other developing countries, under the aegis of the IAEA.

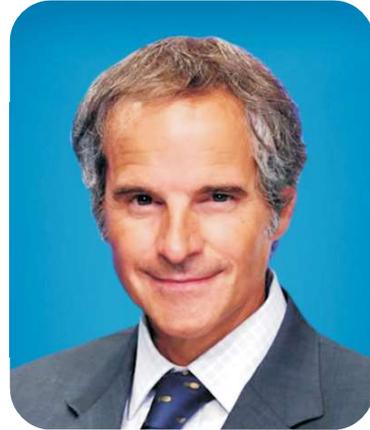
This publication offers a glimpse of Pakistan's achievements as well as what it can offer to other developing countries. In close collaboration with the IAEA, Pakistan looks forward to establishing and expanding fruitful partnerships with interested developing countries to promote the uses of nuclear technology and applications for sustainable development.

(Aftab Ahmad Khokher)



Message by Director General IAEA

Pakistan and the IAEA have decades of experience collaborating successfully on a wide range of endeavours, from boosting crop yields through mutation breeding to introducing cutting-edge cancer care approaches like the nanostics. My recent visit allowed me to see first-hand Pakistan's enhanced capacity to use nuclear science and technology to advance important fields, including human health, low-carbon energy, industry, food security and food safety.



It gives me great pleasure to witness Pakistan's progress and equally to see the country's experts pass on their knowledge to others in the region and beyond. One of the clearest illustrations of Pakistan's achievements and its willingness to support other developing countries, are the three IAEA Collaboration Centres it hosts, advancing food and agriculture, innovative nuclear technology and nuclear security education. Very recently Pakistan has also become one of the inaugural five countries hosting an Anchor Centre for Rays of Hope, providing a regional hub of cancer care support and training. I look forward to continuing our cooperation in the years to come, particularly through IAEA initiatives including Rays of Hope, the Zoonotic Disease Integrated Action (ZODIAC) project, NUTEC Plastics and others.

(Rafael Mariano Grossi)





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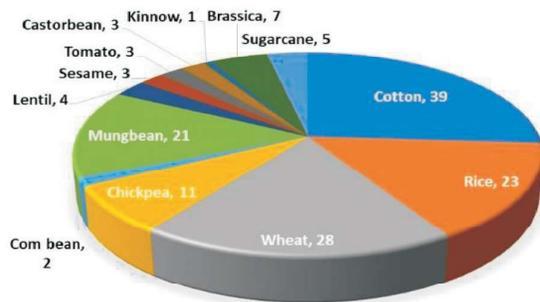
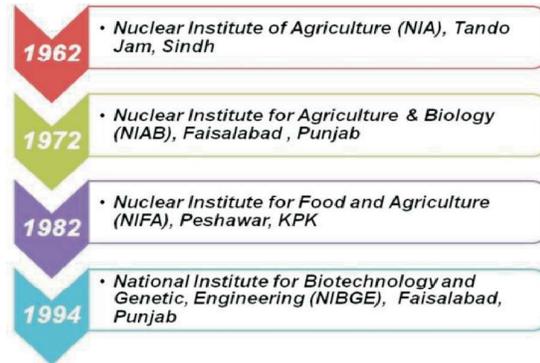


» **Food & Agriculture** »

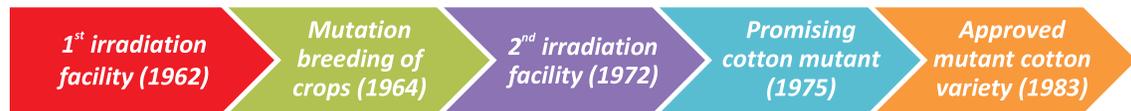
Plant Mutation Breeding



Foreseeing the potential of nuclear technology in food and agriculture and realizing the impact of the agriculture sector in the economic growth of the country, Pakistan Atomic Energy Commission (PAEC) established four agriculture research institutes across the country. These institutes are renowned owing to their great achievements in the fields of plant mutation breeding and associated biotechnologies. These institutes in partnership with the IAEA/FAO have carried out quality research aimed at fostering the development of new crop varieties in the country. To date, 150 new crop varieties have been introduced contributing to food security and socio-economic development of Pakistan.



PAEC Developed Crop Varieties



The first landmark in cooperation with the IAEA/FAO was the development of NIAB-78 cotton variety which stayed in the field for the longest period of time in the history of Pakistan. By introducing this variety, the production of cotton in Pakistan increased from 4.84 million bales in 1983 to 9.63 million bales in 1991-92 which is a proof of the cotton revolution in Pakistan. The IAEA support included training of fellows and infrastructure development. Several



Mutant Cotton Varieties at NIAB, Pakistan

Mutant Cotton Variety NIAB-78 has brought cotton revolution in Pakistan by doubling the production in just ten years

workshops and expert missions were also part of this capacity building program.

PAEC agriculture research institutes impart training at both national and international level including scientists, students, professionals of different institutes & universities and stakeholders of private organizations through training courses, workshops and field demos. Two institutes i.e. Nuclear Institute for Agriculture & Biology (NIAB) and National Institute for Biotechnology & Genetic Engineering (NIBGE) are also constituent colleges of Pakistan Institute of Engineering and Applied Sciences [PIEAS] for academic program to award M. Phil. and Ph.D Degrees in the field of Biological Sciences & Biotechnology.

The facilities and expertise developed by Pakistan in collaboration with the IAEA/FAO are also being offered for the benefit of other IAEA Member States. IAEA has designated Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad as its Collaborating Center.

Major facilities available:

- Gamma Cell 220 (Co-60)
- Mark IV Irradiator (Co-60)
- Gamma Cell 3000 (Cs-137)
- Gamma Counter
- Real Time PCRs
- Photosynthesis System
- Bio-saline Research Station
- Double Beam Spectrophotometer
- UHPLC-MS/MS
- HPLC
- Liquid Scintillation Counter
- Inductively Coupled Plasma - Optical Emission Spectrometer (ICP – OES)
- Gas Chromatograph
- Atomic Absorption Spectrophotometer



Plant Breeding Labs at NIAB



Designation of NIAB as IAEA Collaborating Center



Farmers day at NIAB

Scientists at Pakistan's nuclear research institutes have published their research work in the form of books, journal articles and patents. They have also participated in various international projects including technical cooperation and coordinated research projects. Scientists have also been decorated with high level national and international awards.

Food Safety

Ensuring food safety is important, not only to protect the health of consumers but also to meet the requirements for international trade. Pakistan established its first (ISO/IEC 17025) veterinary drug residue laboratory at the Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad. The IAEA jointly with the FAO supported this venture by providing state of the art equipment, training at various European reference laboratories and expert missions to assist with implementing measurement protocols and methods as well as regular technical advice. The laboratory is capable to identify, monitor and address the presence of antibiotic and hormonal drug residues in livestock.

Pakistan's Established First ISO/IEC 17025 Accredited Veterinary Drug Residue Laboratory in collaboration with the IAEA

Therefore, an integrated, cost-effective and achievable analytical strategy to monitor and control the antibiotic residues is now in place in Pakistan.

With over 600 consignments analyzed, this laboratory provides analytical support to the quarantine departments of the Ministry of National Food Security and Research by analyzing animal meat destined for export. These testing services are also available to the private sector in Pakistan.

With the IAEA support, 129 chemists, food technologists, veterinarians and nutritionists have been trained from



Inauguration of Veterinary Drug Residue Laboratories



ELISA Reader – Specialized Spectrophotometer



Automatic Distillation System

Qualified 12 Proficiency Testings from Progetto Trieste, Italy & FAPAS, UK

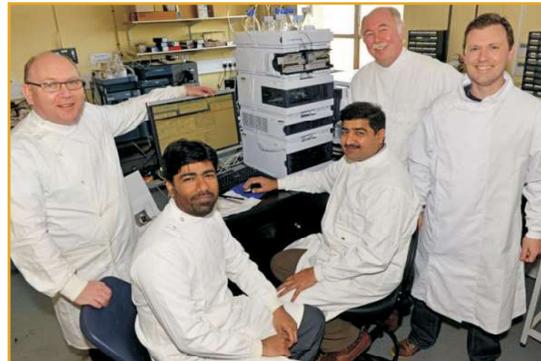
different research organizations at national level in advanced analytical techniques for food safety measures. Around 500 farmers have also been trained on proper production practices.

Facilities and expertise in food safety are being extended for the benefit of other IAEA Member States. An IAEA Regional Training Course on “Proper sampling, use of statistics, risk assessment and ISO/IEC 17025:2017 including Lead Assessor Roles” has been conducted at this laboratory from 28 Nov. - 09 Dec. 2022. Several members of the Food Safety Asia Network also participated in this event. Practical sampling and analysis of veterinary drug residues and aflatoxin M1 were demonstrated in the Residues Analysis Laboratory during the course.

Several fellows have also been trained at this laboratory under the umbrella of the IAEA TCP. More similar activities are in the pipeline.



Mass Spectrometer



Human Resource Development through IAEA TCP



IAEA Regional Training Course



Field tour during the RTC



Fellows from Papua New Guinea

Climate Smart Agriculture



Pakistan is the 8th most vulnerable country to the impact of climate change as per Global Climate Risk Index. Rising temperatures and extreme weather events are increasingly affecting the agricultural productivity leading to harm food security. IAEA jointly with FAO supported Pakistan to optimize and strengthen its capacity in using nuclear and isotopic techniques to improve agricultural resilience and the adaptation to climate change commonly known as Climate Smart Agriculture (CSA) practices. With this assistance, scientists at Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad have been able to assess the impact of climate change to enhance agricultural productivity; better adapt and build agricultural and food security systems resilience to climate change impact and reduce Green House Gases (GHG) emissions in agriculture for food security and sustainable agricultural development.

The IAEA has provided equipment and training to scientists in using isotopic techniques to obtain essential information on how to optimize fertilizer use and increase the efficiency of agricultural production while maintaining soil health.



Atomic absorption spectrometer



Gas chromatograph



Neutron Moisture Meter

Soil salinity is another major problem faced by agricultural land of Pakistan. The IAEA/FAO has supported Pakistan to establish facilities and expertise to address this problem. Scientists use Nitrogen-15 (^{15}N), a stable isotope of Nitrogen, which helps to determine the exact amount of Nitrogen that crops need. Nuclear techniques are used to measure the moisture content of the soil, so that the right amount of irrigation can be applied at the time the plants need it most.

Facilities and expertise established in collaboration with the IAEA/FAO are being extended for capacity building of other IAEA Member States. Following training events have been organized in the subject field during the recent past:

- Group Fellowship of Senegal Nationals in 2019
- NTC on CSA measuring greenhouse gas emissions from agriculture in 2020
- Group Fellowship of Iraqi Nationals in 2022
- Group Fellowship of Burundi Nationals in 2023
- IAEA RTC on CSA in 2023
- Scientific Visit of Azerbaijan Scientists in 2023
- Group Fellowship of Lesotho Nationals in 2023
- Group Fellowship of Iraqi Nationals 2023

NIAB scientists have also conducted several expert missions in the field of climate smart agriculture under the auspices of IAEA. Member States are encouraged to get benefit from the capabilities established at NIAB to help solve their problems in the field of agriculture.



Salt affected land in Pakistan



IAEA fellows during training



IAEA fellows during training



IAEA RTC on Climate Smart Agriculture

Animal Sciences

Pakistan Atomic Energy Commission is actively engaged in the Research & Development work in the field of Animal Sciences. It has established specialized Animal Disease Diagnostic and Vaccine Development Laboratories at the Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad in collaboration with the IAEA. These laboratories are contributing towards poverty alleviation, food security and socio-economic development of the country.

Salient features of Disease Diagnostic Laboratory includes washing and sterilization, microbiological culture and sonication, gene amplification & cloning and ELISA facilities while Vaccine Production Laboratory is designed for culture of animal cells, infection of cells and freeze drying activities in isolated units.



Disease Diagnostic Laboratory



Inauguration of ZODIAC National Lab at NIAB

Following expertise have been developed at these laboratories:

- Disease surveillance and epidemiology
- Molecular and immunological techniques to develop diagnostic assays
- Vaccine production technologies
- Use of bioreactors in viral vaccine production

These laboratories have scored 100% in Inter-Laboratory Tests on Diagnosis of Peste Des Petits Ruminants by Serological and Molecular Methods conducted by the FAO/IAEA in 2019.

Pakistan is also participating in the IAEA's flagship initiative on Zoonotic Disease Integrated Action (ZODIAC) which aims to prevent pandemics caused by bacteria, parasites, fungi or viruses that originate in animals and can be transmitted to humans. Pakistan has established ZODIAC National Laboratory at NIAB, Faisalabad under the framework of this initiative. Pakistan offers its capabilities in the field of Animal Sciences for the capacity building of other Member States.

Capabilities in Disease Diagnostics:		
Diagnostic tests	Diseases covered	National Collaborators
PCR (Polymerase Chain Reaction)/ RT-PCR (Reverse Transcription PCR)	<ul style="list-style-type: none"> • Hemorrhagic Septicemia (HS);Foot-and-mouth disease (FMD);buffalo pox • Rabies; Peste des petits ruminants;Avian pox; Newcastle disease (ND);Angara disease (HPS); Infectious bursal disease (IBD) 	<ul style="list-style-type: none"> • University of Agriculture , Faisalabad • Veterinary Research Institute , Lahore • Provincial Diagnostic Laboratory, L&DD , Lahore • University of Veterinary and Animal Sciences (UVAS), Lahore • National Veterinary Laboratory , Islamabad, • Animal Sciences Institute (ASI), Islamabad
LAMP (Loop mediated isothermal amplification)	<ul style="list-style-type: none"> • Foot-and-mouth disease (FMD) • Peste des petits ruminants • Newcastle disease (ND) • Infectious bursal disease (IBD) 	
ELISA (Enzyme linked immunosorbent assay)	<ul style="list-style-type: none"> • Foot-and-mouth disease (FMD) • Peste des petits ruminants • Newcastle disease (ND) • Avian Influenza 	

Capabilities in Vaccine Development:

Vaccines	Status	National Collaborators
NIAB Hemorrhagic Septicemia (HS) Vaccine	Commercialized and now in registration process	<ul style="list-style-type: none"> • Veterinary Research Institute (VRI) , Lahore • Foot-and-mouth Disease Research Center (FMDRC), Lahore
Peste de petits ruminants (PPR) (eye-drop application)	Developed and under stability studies	<ul style="list-style-type: none"> • University of Veterinary and Animal Sciences (UVAS), Lahore • Aptly Pharmaceuticals Faisalabad
Foot-and-mouth disease (FMD)	Ongoing research	



» Human Health »

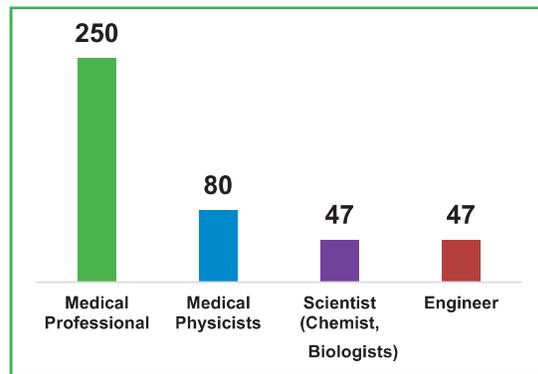
Nuclear Medicine, Radiology and Oncology



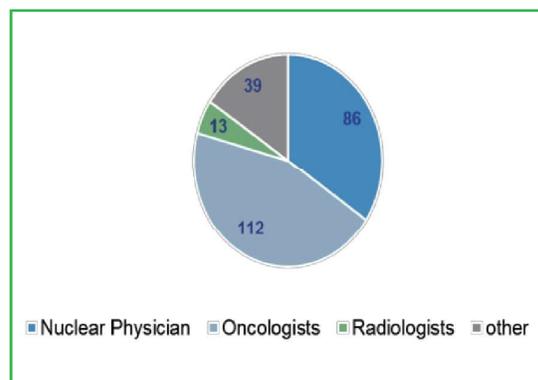
Pakistan Atomic Energy Commission [PAEC] is providing services in use of radiation in health sector since 1960s under the mandate of peaceful, safe and secure application of nuclear technology. PAEC established 19 Atomic Energy Cancer Hospitals (AECs) throughout Pakistan, from North to South. One more hospital is under construction at Muzaffarabad, AJK.

The objectives of radiation based medicine for cancer treatment by PAEC is to:

- Provide state of the art diagnostic and treatment facilities to cancer patients irrespective of their socio-economic status, age and stage of the disease.
- Collect data to assess regional incidence of cancer



Human Resource



Medical Professionals

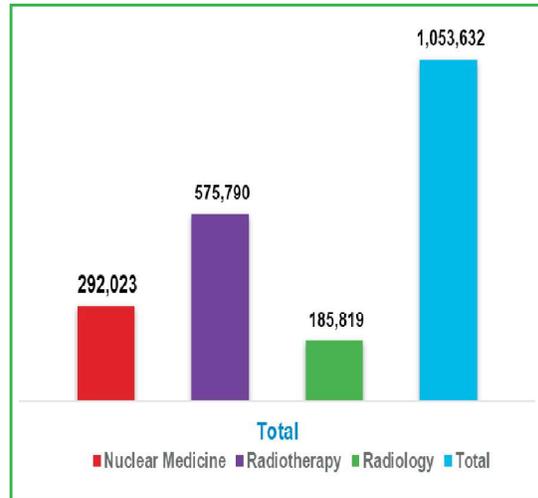
- Create awareness in local population as a step towards primary prevention of cancer.

PAEC provides specialized training to the medical doctors, Scientists and the technical staff to use the radiation in health. Currently there are ~2500 personnel working in these hospitals including ~250 doctors. Our five flagship AECHs are recognized in the fields of Nuclear Medicine, Radiotherapy, Radiology, Medical Oncology, Hematology for the degree programmes of FCPS by college of Physicians and Surgeons, Pakistan. MCPS, DMRT, and DMRD programmes are also being supported through these centers for training and research work.

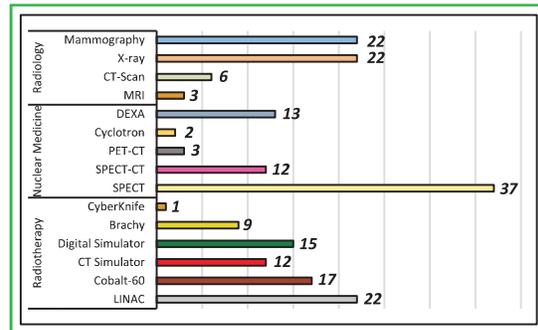
AECHs are providing teaching and training facilities to Postgraduate Doctors (NM, RMO) and Scientist (Medical Physics) in collaboration with Pakistan Institute of Engineering and Applied Sciences (PIEAS) Islamabad.

PAEC Cancer Hospitals cater over 40,000 new cancer cases with 1.0 Million procedures per annum, taking ~ 80 % of the country's cancer burden. Patients receive high quality diagnostic and treatment facilities either free of charge or at subsidized rates at these hospitals. PAEC is doing utmost to cope with the ever increasing patient burden. This requires more spaces, equipment and manpower. Therefore, hospitals are regularly upgraded with the addition of new equipment and replacement of old ones.

AECHs are providing services to the ailing humanity through well-equipped Nuclear Medicine, Radiotherapy and



Annual Patient Turnover for the year 2022



Major Medical Equipment at AECHs



MRI 1.5 Tesla at AECH, MINAR

Radiology departments. AECHs are equipped with latest equipment including SPECT-CT Gamma Cameras, PET-CT Scanners, Cyclotrons, Radionuclide therapy and Theranostics facilities. Linear Accelerators, Cobalt-60 Teletherapy, Cyber Knife, Brachytherapy, Digital Simulator and Treatment Planning Systems are available for radiotherapy department. PAEC keeps on introducing the new technologies into the system like VMAT, IMRT and IGRT. Ancillary radiology equipment like MRI, CT Scanner, digital X-ray, Mammography and ultrasonography /Color Doppler is also available. AECHs are also equipped with up-to-date hematology, chemical and pathology laboratories to give diagnostic tests services along with treatment under one roof.

H.E. Rafael Mariano Grossi, Director General, IAEA has inaugurated Cyber Knife at Nuclear Medicine, Oncology and Radiotherapy Institute (NORI), Islamabad in Feb,2023 which is major milestone for the country.

PAEC has strong tradition of research and development (R &D) activities in AECHs. The hospitals are involved in various new projects including International Atomic Energy Agency (IAEA) Technical Cooperation Projects, Coordinated Research Projects and Regional Agreement projects. In addition, students from local universities and colleges are also conducting research projects in these AECHs.

IAEA has always supported Pakistan in capacity building and human resource



LINAC installed at AECH, KIRAN



Inauguration of Cyber Knife at AECH NORI



Cyber Knife at AECH NORI

development of PAEC's Cancer Hospitals. One AECH, i.e. NORI, has been designated as an Anchor Center under the flagship initiative of IAEA "Rays of Hope" and will support regional countries in cancer treatment access.

IAEA is providing continuous support to Atomic Energy Cancer Hospitals (AECHs) in the area of cancer focusing on medical uses of radiation.

- CT simulator at INOR, Abbottabad
- Theranostics lab at INMOL, Lahore

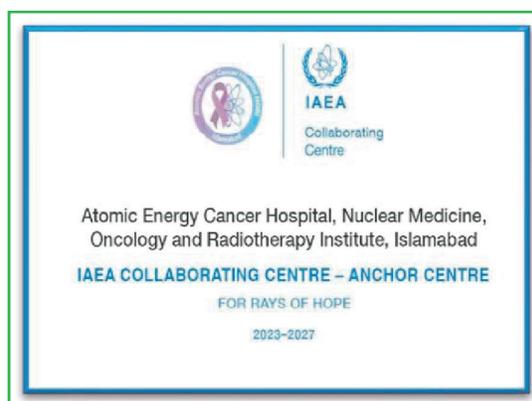
In Pakistan, Institute of Nuclear Medicine & Oncology (INMOL), Lahore is the pioneer to introduce "Theranostics" in the country in collaboration with the IAEA. It is a modern day cancer care method used by combining therapeutic and diagnostic radiopharmaceuticals.

Diagnostic investigations introduced in Pakistan include:

- Ga-68 based DOTA-NOC PET scan for neuro-endocrine tumors (NETs)
- Ga-68 based PSMA PET scan for prostate cancer
- Copper-64 based PET scan for prostate cancer and brain glioma

The treatment procedures available at various AECHs:

- Lu-177 based DOTATATE therapy for neuro-endocrine tumors (NETs)
- Lu-177 based PSMA therapy for prostate cancer
- Ac-225 based ALPHA therapy with PSMA and DOTATATE for prostate and NETs
- Y-90 based DOTATATE therapy for NETs



NORI Designated as Anchor Centre of Rays of Hope Initiative



Linear Accelerator at NORI, Islamabad



Digital Mammography at AECH, MINAR Multan

Pakistan is ready to share facilities and expertise developed in the field of Theranostics at INMOL, Lahore, and NORI, Islamabad, with other Member States under the auspices of IAEA.

IAEA plays an important role in spreading knowledge through training, courses, fellowships, workshops, conferences & seminars.

Medical professionals and physicists from AECHs attended IAEA training courses, fellowships, scientific visits, conferences, seminars, congress, workshops. IAEA Experts visits also help AECHs in boosting their skills.

IAEA is providing continuous support to Atomic Energy Cancer Hospitals (AECHs) in the area of cancer focusing on medical uses of radiation.

Pakistan Atomic Energy Commission (PAEC) and other member states may cooperate in the field of health sector as follows:

- Atomic Energy Cancer Hospitals (AECHs) can host capacity building of human resources through its teaching and training programs for the undergraduate as well as postgraduate Medical students. Various AECHs are recognized by College of Physicians and Surgeons Pakistan (CPSP) for FCPS training in Radiation and Medical Oncology, Nuclear Medicine, Radiology. AECHs also arrange specialize courses like DMRT, DMRD, in affiliation with various universities.
- AECHs may offer short training / courses for technical personnel in the fields of Nuclear Medicine,



**CT simulator at INOR, Abbottabad
NORI Designated as Anchor Centre of Rays of Hope Initiative**



MR Simulator at NORI, Islamabad



Fully Automated Theranostics

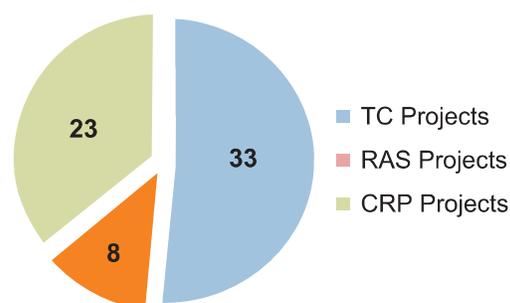
Radiotherapy, Radiology, Medical Oncology, Medical Physics and Radiation Protection of Patients.

- Pakistan Institute of Engineering and Applied Sciences (PIEAS) is the degree awarding University in field of Radiation and Medical Oncology, Nuclear Medicine and Medical Physics. Manpower can be trained through PIEAS Academic Programs.
- The countries may cooperate in production/ Application of radioisotopes for medical use especially the unsealed sources used in Nuclear Medicine like Molybdenum-99/Technetium-99m generators, Iodine-131. We may also share experiences in production of cold kits used in Nuclear Medicine.
- PAEC may enhance cooperation with member states through IAEA training programs and TC projects. PAEC has ever since interacted with the Department of Technical Cooperation of IAEA from planning to finalization of TC projects in various disciplines including nuclear application in health sector.
- PAEC may help institutes of member states in the field of Theranostics, as Various AECHs are practically involved in patient's treatment and R&D of aforementioned field.

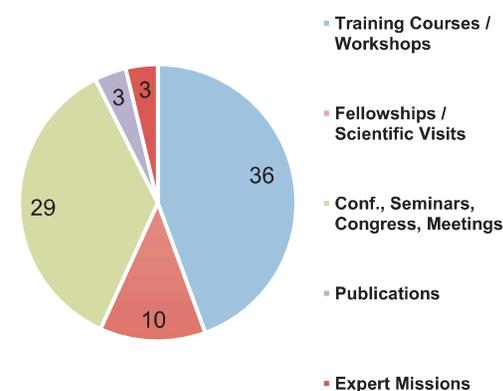


GE Fast Lab 2

IAEA Research Projects - 2010 onward



IAEA support for improving HR Experties (2016 to 2022)



Production and Supply Chain Management of Radiopharmaceuticals

PAEC is managing the production and supply chain of two most important radioisotopes as well as freeze dried cold kits employed as radiopharmaceuticals at Pakistan institute of nuclear science & technology (PINSTECH) using PARR-1. PAEC is producing M-99/Tc-99m generators through fission Mo-99. Tc-99m is used in more than 80% diagnostic cases of cancer all over the world. Another radioisotope, I-131 is used for the diagnosis and therapy of thyroid cancer is also produced in PAEC. The production procedures of radiopharmaceuticals follow European pharmacopeia in QC tests. These radiopharmaceuticals are dispatched on weekly basis to nuclear medical centers/hospitals in public and private sectors, all over Pakistan.

PAEC is also part of IAEA Comprehensive Technical project Pak-6027, which is about enhancing and strengthening nuclear medicine and oncology institutions of Pakistan in cancer diagnostics, treatment and ensuring human safety by adopting best practices in cancer management.

Sr	Products	Consignments	Activity (Ci)
1	Tc-99m generators	1885	847
2	I-131 vials	922	237
3	Adenosine Injections	34,053	
4	Freeze dried cold kits	22,168	-

Radiopharmaceutical production of PAEC in 2022



Isotope Hydrology

Nuclear techniques have a great potential for its applications in hydrology and environment. The interest in these techniques is growing worldwide due to their cost economics, less time consumption and ability to provide information, which sometimes cannot be obtained with other techniques. Pakistan Institute of Nuclear Science and Technology (PINSTECH) has established state of the art Isotope Hydrology Laboratories in collaboration with the IAEA. The capabilities developed in the following specific areas can be extended for the training of other Member States through the IAEA:

- Origin, age and residence time of groundwater
- Mechanism of groundwater recharge
- Interconnection between shallow and deep aquifer systems
- Hydraulic relationship between dam reservoirs and associated groundwater systems
- Causes of water logging & salinity
- Dam safety and sustainability
- Contaminant transport in unsaturated zone
- Groundwater flow velocity and flow direction
- Soil erosion and related transport / accumulation of sediment
- Estimation of seepage losses from canals
- Determination of porosity, permeability & hydraulic conductivity
- Study the effect of climate change on glaciers



DG IAEA visiting Isotope Hydrology Labs at PINSTECH



Finnigan Delta Plus Advantage Mass Spectrometer



Modified GD-150 Mass Spectrometers for $^2\text{H}/^1\text{H}$ and $^{18}\text{O}/^{16}\text{O}$ & $^{13}\text{C}/^{12}\text{C}$

The Isotope Hydrology Laboratories at PINSTECH have served as Regional Resource Unit of RCA and provided services to various countries including Bangladesh, Egypt, Ethiopia, Indonesia, Iran, Jordan, Korea, Libya, Malaysia, Mongolia, UAE, Madagascar, Morocco, Philippines, Saudi Arabia, Sri Lanka, Syria, Tanzania, Thailand, Tunisia, Uganda, Vietnam and Zambia.

These laboratories have participated in various inter-comparison tests at the IAEA level including:

- WEPAL (Wageningen Evaluation Programs for Analytical Laboratory)
- WICO (Water Isotope Inter-Comparison Test)
- NICO (Nitrogen Inter-Comparison)
- TRIC (Tritium Inter-Comparison)

National Collaborators:

- Nuclear Power Plants of PAEC
- Water and Sanitation Agencies (WASA)
- Water & Power Development Authority (WAPDA)
- Pakistan Council of Research in Water Resources (PCRWR)
- Irrigation Research Institute (IRI)
- Universities
- Oil and Gas Development

IHL has contributed for Human Resource Development in regional countries by hosting on-job training, organizing group-training courses & meetings, supervising fellowships and scientific visits. Workshops and IAEA RCA Review Meetings.



Liquid water isotope analyzer (LWIA) for D/H and $^{18}\text{O}/^{16}\text{O}$ from Los Gatos



Rad-7 for radon measurement in water and soil

Recently a regional training course on “Enhancing water resources management through isotopic techniques” was conducted in August 2023 under IAEA/RCA.

IAEA celebrated the 50th anniversary of RCA in 2022 and PINSTECH had the distinction to receive two awards one in the individual category to Dr. M Azam Tasneem former member of IHL and other as institute category for PINSTECH due to its valuable contribution in various areas of applications of nuclear science and technology including Isotope Hydrology, Water Resources Management, Industry and Air & Marine Pollution.



Industry

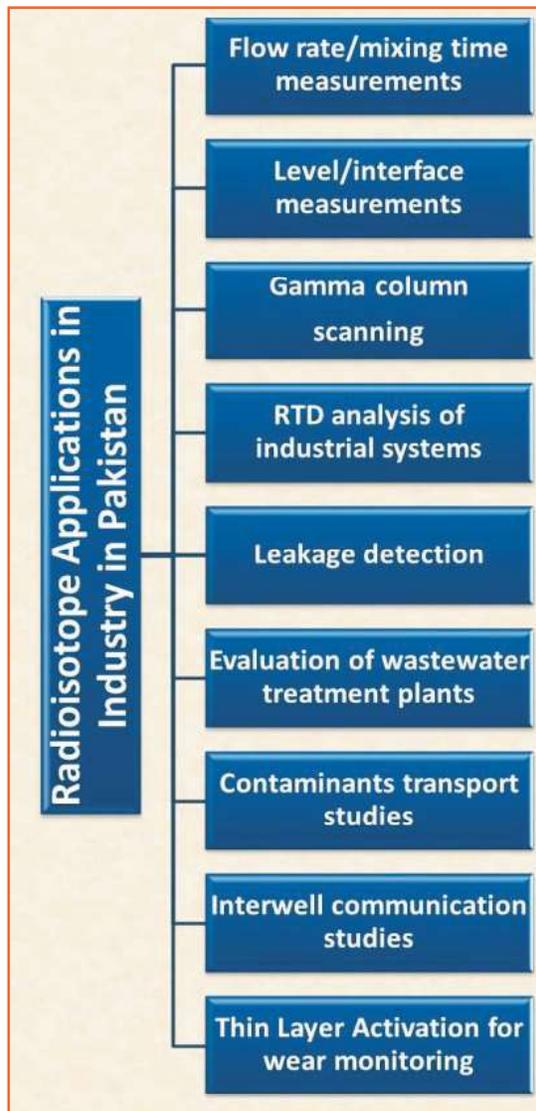


Radiotracer and Sealed Source Applications in Industry

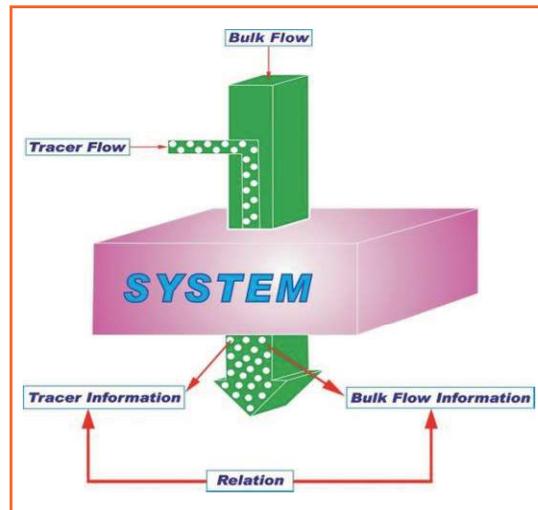
Radioisotope techniques continue to play an important role in raising industrial productivity leading to better management of natural resources. Pakistan Institute of Nuclear Science and Technology [PINSTECH] in collaboration with IAEA has established unique facilities and expertise to provide radioisotope technique based services to address conventional industrial problems.



Benefits of Radioisotope Application in Industry



Radioisotope Applications in Pakistan



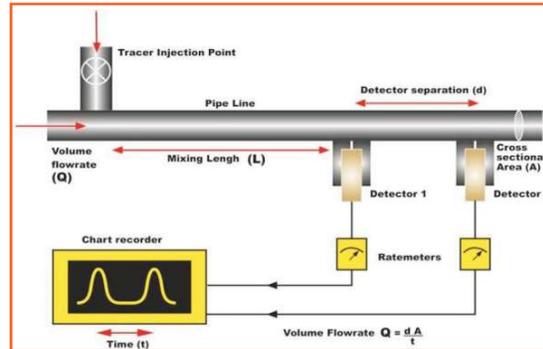
Principle of Radiotracer Application in Industry



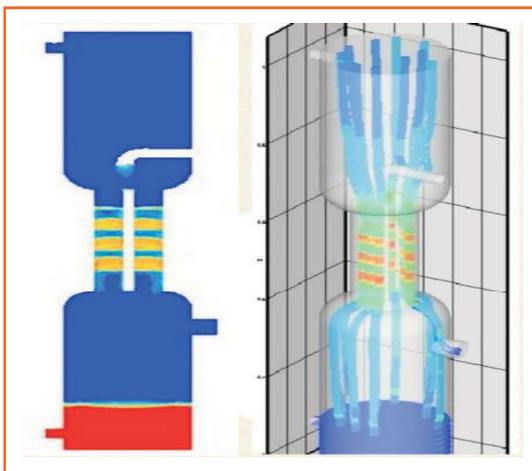
Radiotracer Data Acquisition System

The capacity built for conventional radioisotope applications has provided us a suitable foundation to enhance our scientific research to investigate complex industrial multiphase systems through innovative techniques including:

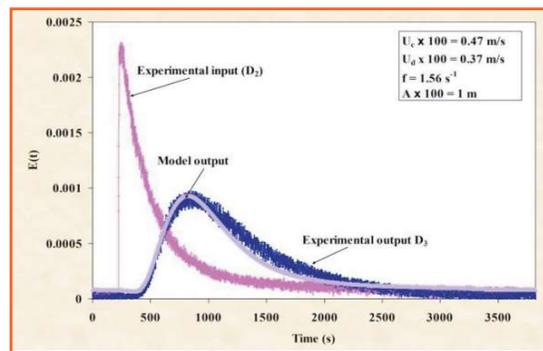
- Process Gamma Computer Tomography
- Radiotracer Residence Time Distribution (RTD) Analysis
- Computational Fluid Dynamics (CFD) Simulation



Flow rate measurement in pipelines

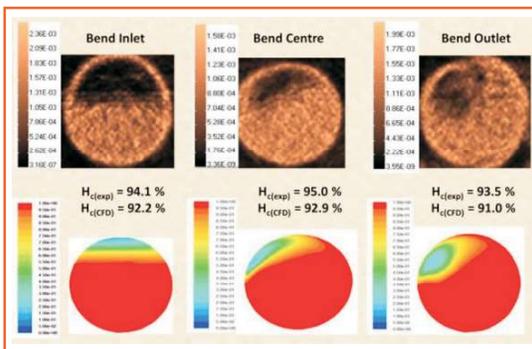


CFD Simulation of a pulse column



Residence Time Distribution (RTD) analysis in a pulse column

Pakistan is ready to share its capabilities established in collaboration with the IAEA in the domain of radioisotope applications in industry with other Member States in the form of training and expert services.



Experimental and CFD results of two phase flow across a 90° bend

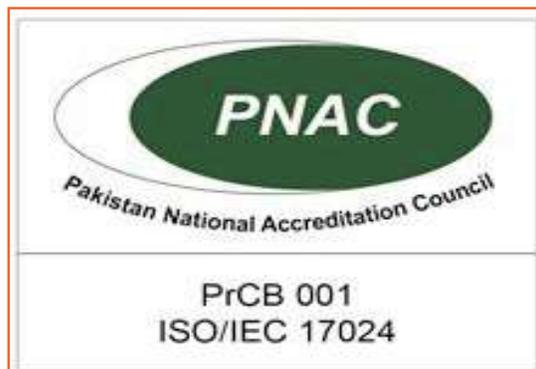


Gamma Tomography of Two-Phase Flows

Non Destructive Testing (NDT)

Pakistan established a National Center for Non-Destructive Testing (NCNDT) under Pakistan Atomic Energy Commission (PAEC) in 1986 with the aim to respond to the increasing demand for NDT services in the country. Through collaboration with the Regional Cooperative Agreement (RCA) under the auspices of the IAEA, scientists/engineers of NCNDT got professional training through participation in regional projects. Since then, several NCNDT professionals have been trained and certified on NDT techniques at international institutes through IAEA/RCA. These qualified professionals designed a national curriculum of various NDT courses leading to the establishment of a National Certification Scheme.

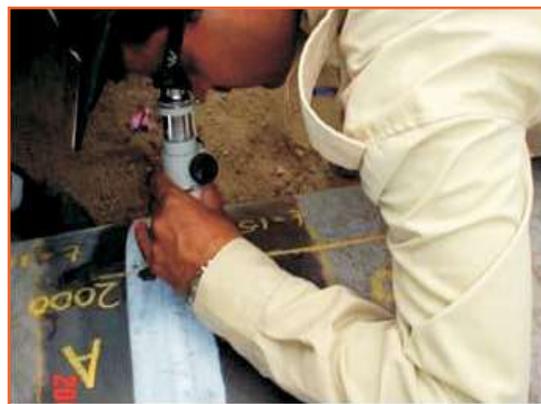
NCNDT has been accredited by Pakistan National Accreditation Council (PNAC) as a certification body for Personnel Certification in NDT and is the first personnel certification body accredited by PNAC as per standard ISO/IEC 17024:12.



Penetrant testing of generator rotor blades at a power plant

Services offered by NCNDT:

- Inspection and Testing Services to Industry
- Pre-service and In-service Inspections of NPPs
- Third Party Inspection and Evaluation Services
- Equipment Calibration Services
- Mechanical and Metallurgical Testing Services
- Failure Analysis and Life Assessment
- Structural Integrity Analysis
- Surveillance program of NPPs



In-situ hardness testing of pipe at a Gas Well



NDT Certification Laboratory

Following are the Level-1, 2 & 3 Certifications introduced at NCNDT, Pakistan in collaboration with IAEA/RCA:

- Liquid Penetrant Testing
- Magnetic Particle Testing
- Radiographic Testing
- Eddy Current Testing
- Ultrasonic Testing
- Leak Testing
- Visual Testing

Recently, courses on Digital Radiographic Testing, Phased Array Ultrasonic Testing and Time of Flight Diffraction have also been conducted at the NCNDT.

- **Around 20 NDT Courses are conducted at NCNDT per year**
- **Around 200 trained professionals are produced per year by the NCNDT**

The NCNDT acts as the Secretariat for the Pakistan Society for Non-Destructive Testing (PASNT). Main aim of the PASNT is the development and promotion of NDT technology in the Country. Pakistan is also a member of the International Committee for Non-Destructive Testing (ICNDT).



Lecture during a training session at NCNDT

NDT program established in collaboration with the IAEA/RCA has created awareness and encouraged the local industry to uptake the technology. Several information dissemination activities including seminars and conferences have been organized at the national level.

03 additional local NDT training centers have been established at private level

End-user Industries:

- Nuclear Industry
- Oil and Gas Industry
- Power Generation Industry
- Petro-chemical Industry
- Manufacturing Industry

Pakistan in collaboration with the IAEA/RCA has established a pool of local experts who have contributed to the development of a comprehensive NDT infrastructure in the country. These experts are available to train more professionals at national as well as international level.

Secondary Standard Dosimetry Laboratory

Secondary Standard Dosimetry Laboratory (SSDL), PINSTECH is playing a pivotal role in standardization of radiation dose measurement of radiation workers and radiation dose delivery to the cancer patients being treated in Pakistan. IAEA helped in establishing the lab through four TC projects during 1979-2015. The lab is ISO 9001:2015 certified and maintaining internal and external quality audit programs. It has strong association with WHO/IAEA network of SSDLs. Radiation protection instruments and therapy level dosimetry systems used in all nuclear installations including nuclear power, health, industry and agriculture sectors in Pakistan are being standardized on regular basis. Currently, 40 radiotherapy hospitals and 300 organizations of the country are availing calibration services at therapy as well as at protection (for alpha, beta, gamma, x-ray and neutron radiations) levels.

SSDL has been regularly participating in IAEA postal dose inter-comparison exercise since 1985 and had earned excellent record of dose delivery. The error in dose delivery has been found to be within IAEA acceptable error limits of $\pm 3.5\%$ and $\pm 7.0\%$ at therapy and protection levels respectively.

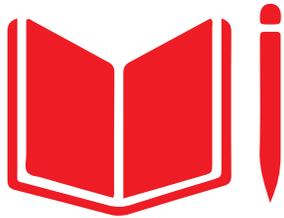
New building, SSDL-II with two irradiation bunkers equipped with semi-automatic irradiation trolleys have been constructed and set into operation to meet the increasing workload of calibration of radiation measuring equipments in the country. The laboratory has planned to increase its scope of work due to the increasing nuclear activities in the country by installing deep therapy X-ray machine (20kV-320kV) and to be accredited as per ISO/IEC 17025 standard. All reference dosimetry systems has been got standardized from IAEA and the deviation had been within the limit of -0.2% to +0.4% for the last 40 years.



Inauguration of SSDL-II at PINSTECH



SSDL Lab at PINSTECH



Education



Nuclear Science and Technology Education



Pakistan Institute of Engineering and Applied Sciences (PIEAS) was chartered as a public sector university in the year 2000. The journey started back in 1967 with the establishment of Reactor School. It is the only Pakistani University which offers higher education in the field of Nuclear Science and Technology and allied disciplines. In a relatively short span of time, it has emerged as one of the best

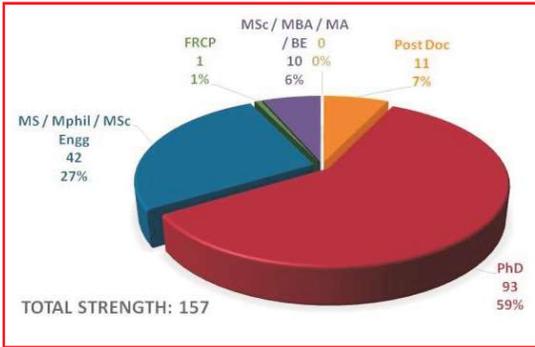
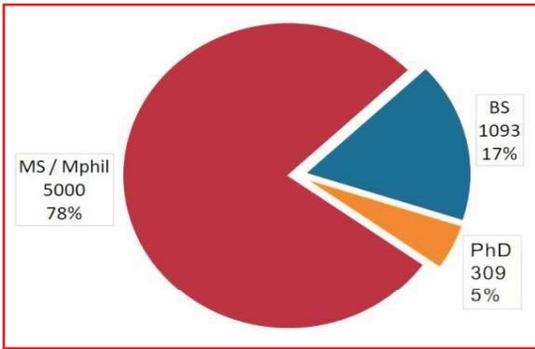
Ph.D Degree Programs	M.S Degree Programs	BS Degree Programs
- Nuclear Engg.	- Nuclear Engg.	- Chemical Engg.
- Chemical Engg.	- Nuclear Power Engg.	- Electrical Engg.
- Electrical Engg.	- Systems Engg.	- Mechanical Engg.
- Material Engg.	- Mineral Res. Engg.	- Met. & Mat. Engg.
- Mechanical Engg.	- Electrical Engg.	- Comp. & Info. Science
- Physics	- Mechanical Engg.	- Physics
- Medical Physics	- Met. & Mat. Engg.	
- Radiation Physics	- Process Engg.	
- Chemistry	- Radiation Physics	
- Computer Science	- Medical Physics	
- Biotechnology	- Nuclear Medicine	
- Biological Sciences	- Physics	
	- Rad. & Med. Onc.	
	- Chemistry	
	- Computer Science	
	- Cyber Security	
	- Biotechnology	
	- Biological Sciences	



universities of Pakistan as indicated by national and international university rankings.

PIEAS has been a source of trained human resource for Pakistan since decades. This human resource is contributing toward the socio-economic development of the country. PIEAS's highly qualified faculty coupled with excellent infrastructure is instrumental in its endeavor to offer high quality education in the disciplines of engineering and applied sciences. It fulfills national and regional requirements for highly qualified professionals.

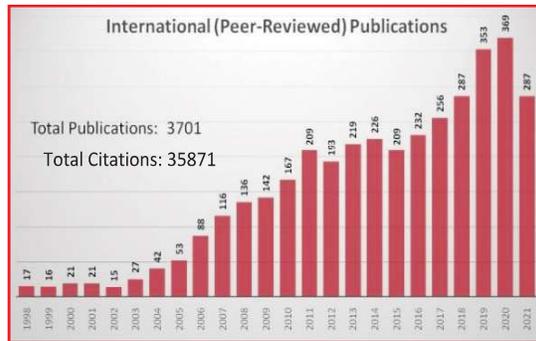
An auspicious outcome of research program is that PIEAS faculty and



researchers have produced about 700 publications in the last five years. The work done by PIEAS faculty and researchers has application in industry which is reflected by wide citation of these publications.

PIEAS has always embraced international students for studies. 43 MS level students from various countries around the world have completed their MS degree from PIEAS.

PIEAS is designated as IAEA Collaborating Centre to support Member States on research, development and capacity building in the application of advanced and innovative nuclear technologies.



PIEAS is working as a partner institute of the IAEA in Marie Sklodowska-Curie Fellowship Programme (MSCFP) by offering fee waiver and accommodation. Several female fellows have completed their MS level studies in various fields of nuclear science and technology under this program. Fellows from the IAEA MSs are encouraged to apply for fellowship at PIEAS under MSCFP.

PIEAS also runs STEM Careers Program jointly with Higher Education Commission (HEC) of Pakistan to inspire the potential youth of the nation to pursue careers in Science,



Technology, Engineering and Mathematics (STEM). PIEAS is also providing expertise for the development of the curriculum for the International Nuclear Science Olympiad, an initiative supported via IAEA TC Project RAS 0091 on NST Education.



» Partnership with IAEA »

Enhancing South-South Cooperation

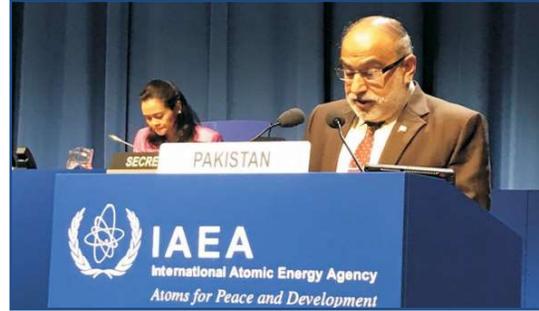


Pakistan is a founding member of the International Atomic Energy Agency (IAEA) and has been actively participating in the deliberations of its Policy Making Organs i.e. General Conference and the Board of Governors. Pakistan has been a major beneficiary of the IAEA's Technical Cooperation Programme TCP for decades. Presently, Pakistan is implementing its 4th Country Program Framework (CPF) with the IAEA encompassing following priority areas:

- Food and agriculture
- Human health
- Water resource management
- Nuclear safety
- Radioactive waste management
- Nuclear power development
- Industrial applications
- Climate change and environmental protection
- Nuclear security and physical protection

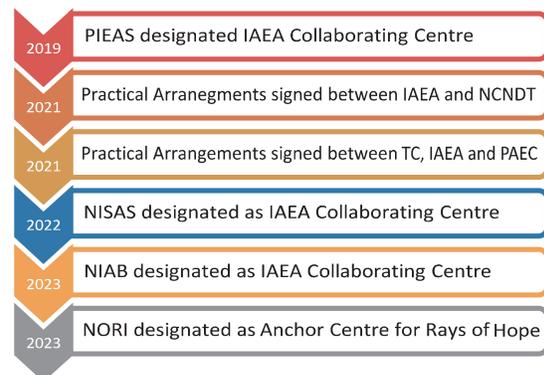
Pakistan has a vast experience of designing and implementing technical cooperation projects. It has successfully implemented 20 TC projects at the national level during the past ten years. Pakistan has also participated in 78 regional/inter-regional TC projects during this period.

Under the auspices of IAEA, Pakistan has organized Fellowship Trainings,



During the recent past, Pakistan has aligned its TCP with IAEA's Medium Term Strategy (MTS) by designing and implementing comprehensive national TC projects aimed to achieve substantial output. One such project has been successfully implemented while three others are under implementation. This strategy has been proved beneficial and Pakistan is ready to share its experiences with other Member States.

Pakistan-IAEA TC partnership is a two-way traffic. On one end, it has strengthened our national capacity while on the other end; Pakistan has shared its capabilities to support other Member States. This partnership has further strengthened during the recent past. The IAEA has designated three (03) of Pakistan's institutes as its Collaborating Centers while two (02) others have signed Practical Arrangements with IAEA.



Recent Milestones of Pakistan-IAEA Collaboration

Scientific Visits, Workshops and Regional Training Courses at its various institutes. Pakistan is working with IAEA to support other Member States through participation in IAEA Expert and Review Missions and representing in various review committees. Pakistan is a member of various Advisory Groups formulated for the purpose of advising Director General IAEA in various matters related to applications of nuclear science and technology.

Pakistan is partnering with the IAEA to support its new initiatives for global socio-economic development.

Pakistan has been working for the promotion of nuclear science and technology by organizing exhibitions and demonstrations at national and international level. Pakistani institutes and scientists have been decorated with Out-Standing Achievement Awards by the IAEA/RCA.

Pakistan has a very good experience of Triangular Cooperation with other Member States involving IAEA. We are ready to offer our capabilities and expertise for the benefit of other Member States on the similar lines.



Signing ceremony of NISAS as IAEA CC



Partnerships in IAEA's New Initiatives



Marie-Curie Fellows with DG IAEA



Tri-angualr Cooperation with China



Pakistan stall during GC-65

Contacts



Mr. Amer Manzoor
Director General International Affairs
IAEA National Liaison Officer
Pakistan Atomic Energy Commission
(PAEC)
P. O. Box: 1114, Islamabad, Pakistan
E-mail: manzoor_amer@yahoo.com
T: +92-51-9201862
C: +92-300-8501577
F: +92-51-9204908



Dr. Ghiyas Ud Din
Minister Technical
Permanent Mission of Pakistan to
the United Nations, Embassy of
Pakistan
Hofzeile 13, A-1190, Vienna, Austria
E-mail: g.mintpk@yahoo.com
T: +43-1-3692404;
C: +43-676-7388339;
F: +43-1-3687376



Dr. Muhammad Shahzad
Director International Cooperation
IAEA National Liaison Assistant
Pakistan Atomic Energy Commission
(PAEC)
P. O. Box 1114, Islamabad, Pakistan
E-mail: ic3022@outlook.com
T: +92-51-9246034
C: +92-336-0600505
F: +92-51-9204908



Mr. Muhammad Waqas Sherani
**Act Director General International
Cooperation and Human Resource**
IAEA National Liaison Assistant
Pakistan Nuclear Regulatory Authority
(PNRA)
P. O. Box: 1912, Islamabad, Pakistan
E-mail: waqas.sherani@pnra.org
T: +92-51-9261061
C: +92-333-9965863
F: +92-51-9263007



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