Training activities in physical and chemical sciences

IAEA laboratories train scientists and technicians from developing countries

by A.A. Abdel-Rassoul

The IAEA Physics-Chemistry-Instrumentation (PCI) laboratory at Seibersdorf, Austria, trains scientists and technicians from developing countries in a wide variety of disciplines associated with the use of nuclear methods and related technologies.

Training courses focus on areas such as environmental and pollution control, analytical chemistry, purity control of nuclear materials, dosimetry, isotope hydrology, nuclear electronics and instrumentation, and computer programming and maintenance. PCI also organizes group training for selected fellowships for periods up to 6 months; and in-service training for periods ranging from 2 months to 1 year.

The programmes for in-service training are divided into four areas: chemistry, nuclear instrumentation, dosimetry, and isotope hydrology. These areas reflect the organizational structure of the PCI laboratory.

Chemistry

The chemistry unit supports the Agency's programmes through analytical chemistry services and training programmes designed to increase the technical ability of specialists from developing countries in analytical chemistry. Up-to-date advanced training, which covers different aspects of modern nuclear- and other micro-analytical techniques, involves determination of trace elements in various inorganic materials, in biological substances and foodstuffs, in nuclear fuel elements, in soils, rocks and minerals, in rain and other natural waters, as well as the determination of radioactive contaminants in food products and environmental components.

At present, emphasis is placed in the determination of trace elements and radionuclides in biological and environmental samples, including individual foodstuffs, total diet, precipitation, air filters, plant materials, and soil. In addition, major and minor elements are also determined in mineralogical samples.

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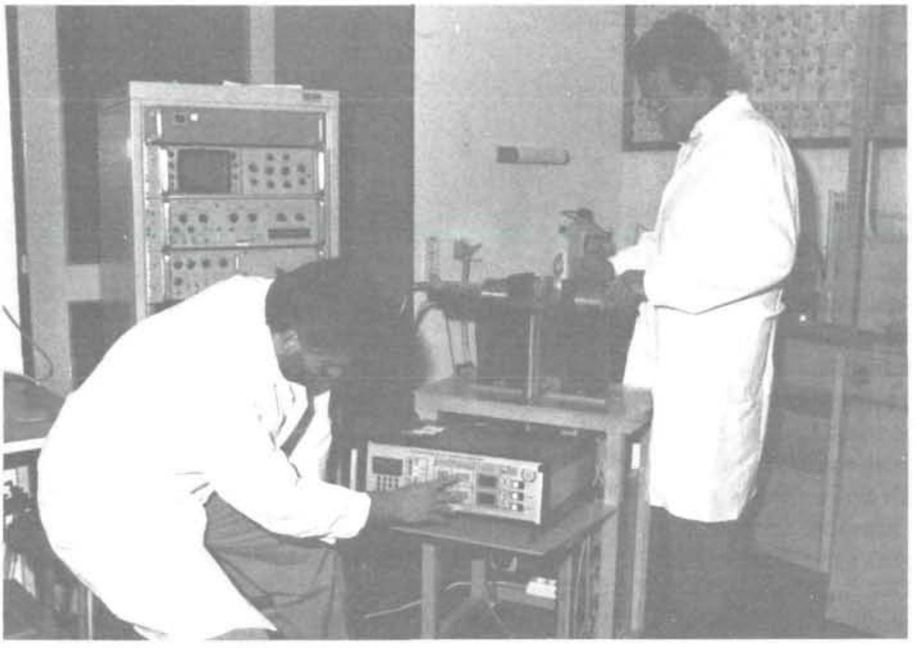
For this purpose, the chemistry unit provides training and guided research involving the use of the various techniques, and offers quality control services for several analytical laboratories covering the following:

Neutron activation analysis. The determinations of trace elements in different matrices by neutron activation analysis (NAA) are accomplished through neutron irradiation in the ASTRA reactor of the Austrian Research Centre at Seibersdorf followed by radiochemical processing and/or nuclear spectrometric measurements. Various types of detectors and nuclear measuring instruments are available and are used to measure each individual activation product with the aid of computer spectra evaluation. Achievable limits of detection are in the range of 1 nanogram/gram (ng/g) to 100 ng/g for most of the trace elements of nutritional and environmental interest.

Fluorimetry. Conventional and laser fluorimetry are used for the determination of trace levels of uranium in different waters, biological and food materials, and in mineral samples. The detection limits attainable by using the laser fluorimeter are of the order of 0.05 ng/g in water samples and 0.05 microgram (μg/g) in most minerals.

Atomic absorption spectrometry. The unit is equipped with an atomic absorption spectrophotometer (ASS) which has a microprocessor-controlled system with display, automatic control for background correction (deuterium-lamp), and signal and data processing. This instrument is mainly used for the determination of ultra micro-amounts of chemical elements by the graphite furnace and cold vapour techniques, and for the determination of metallic hydride-forming elements through a number of metal hydride separation procedures.

Inductively coupled plasma (ICP) emission spectroscopy. The ICP emission spectroscopy instrument is equipped with a combined emission spectrometer for simultaneous and sequential measurements. The polychromator for the simultaneous measurements has an outfit for 18 elements. The monochromator can be used



A microprocessor-based controller device used in density measurements of soil samples, designed by a trainee and constructed by the instrumentation unit of the PCI laboratory.

for the analysis of nearly all elements in the periodic table.

Radioactivity measurements. Training also covers operation of the various types of nuclear spectroscopic measuring instruments used to assess low-level radioactivity of different nuclides. These measurements are performed to monitor food and environmental contamination, to determine natural radioactivity (uranium, radium, and thorium-series) in soil and other geological samples, and to measure radioisotopes produced in nuclear-induced processes. Complete systems for gamma spectrometry, liquid scintillation counting, alpha-beta scintillation counting, and alpha counting and spectrometry are available. A number of special instruments are available for training in nuclear measurements, including multichannel analysers, radiation detectors, and spectrometers.

Quality control services for analytical laboratories. The chemistry unit provides demonstrative training in quality control through performance and organization of intercomparisons involving several analytical laboratories. Since 1959, the Agency has conducted the Analytical Quality Control Services (AQCS) programme. Reference materials are prepared and distributed to numerous laboratories in Member States. They are used continuously for assessment of low levels of radioactivity, spectral analysis, determination of minor and trace elements, determination of the ratios of stable isotopes, and analysis of certain organic compounds in various matrices.

In all cases, depending on the educational background and professional experience of the person to be trained, problem-oriented research can be carried out to improve, for example, the detection limits through proper sampling and sample processing.

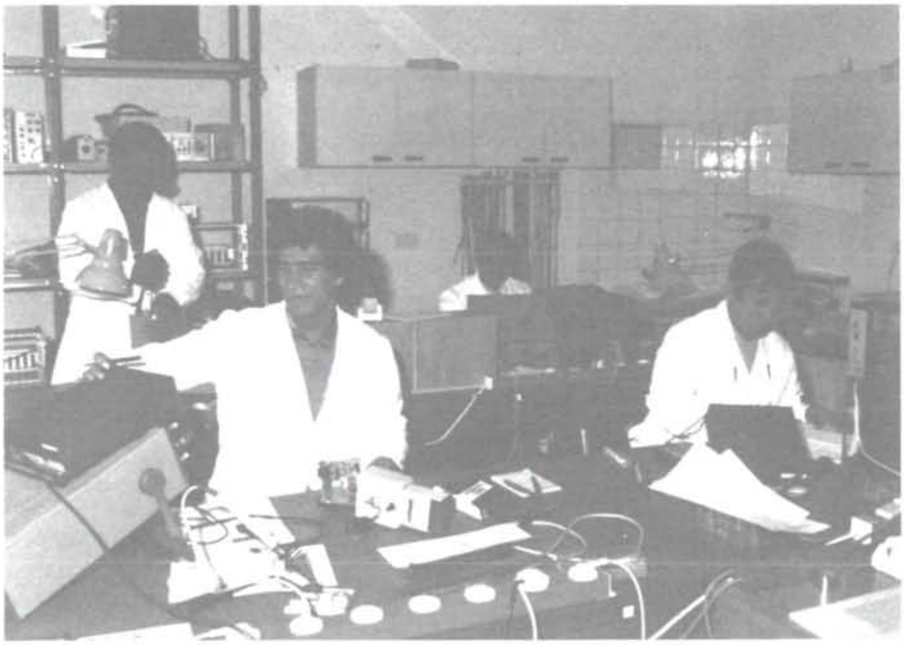
Nuclear instrumentation

Training activities in the instrumentation unit include individual and group fellowship training. Electronic technicians and engineers from developing Member States become acquainted with circuit design, construction and operation of nuclear measuring instruments. They acquire practical experience in running control tests, performing maintenance, services, and repairing malfunctioning equipment.

Individual on-the-job training began in 1980. Today, more than 80% of the requests approved by the Agency's Division of Technical Assistance and Co-operation have been accommodated in the instrumentation unit. Individual programmes are planned to meet the needs and technical ability of each trainee. The trainees initially gain basic knowledge and experience in nuclear electronics, and in proper handling and use of testing instruments and repair tools, and necessary background information for the design and construction of various types of instruments commonly used in nuclear measurements.

Through supervision and continuous guidance, the trainees gain experience in the maintenance and repair of electronic equipment. They are trained in the design and construction of more elaborate measuring instruments after becoming acquainted with the theory of microprocessors, design of hardware, and programmes.

For example, a trainee recently designed and constructed a microprocessor-based controller device used in density measurements of soil samples through attenuation of the gamma rays emitted from caesium-137 and americium-241. Another trainee designed and constructed a radiocarbon dioxide controller, which is now used in a technical co-operation project in Pakistan. He also designed and assembled a noise generator for



Group fellowship training in nuclear spectroscopy instrumentation maintenance.

educational purposes in nuclear instrumentation maintenance training.

Since 1983, 21 fellows from 18 countries have received individual on-the-job training. Each year four to six trainees are accepted for periods ranging from 6 to 12 months. This type of personalized training requires concentrated efforts in guidance and supervision over expanded periods of time. The candidates ultimately gain sufficient experience to act as trainers themselves when they return to their home countries.

To meet the increased number of requests to train national specialists from developing countries, and to maintain suitable maintenance and repair service capabilities in such countries, group fellowship training in nuclear spectroscopy instrumentation maintenance was initiated in 1986. Limited to 6 months and generally involving six to eight trainees, this group optimizes the training capability of the laboratory. Emphasis is placed on nuclear instruments including the computer-serviced instruments used in spectroscopic measurements which are performed in most research and development control laboratories. This type of training involves major trouble-shooting of factory-made nuclear instruments such as semi-conductor detectors, preamplifiers, amplifiers, low- and high-voltage power supplies, and microprocessor-based multichannel analysers. Block diagram and circuit diagram analysis of various models of factory-made spectroscopy instruments (as well as maintenance practice and trouble shooting with proper use of measuring instruments) are emphasized.

After the trainees have gained basic knowledge and experience in the operation and service of detectors, analog, digital, microprocessor, and computer components, repair of other kinds of nuclear electronic instruments comes easy. These include most of the instruments used in most research and service laboratories, nuclear medicine, agriculture, health physics, and hydrology.

Some fellows are occasionally permitted to conduct additional on-the-job training by extending their training period.

In co-operation with the Agency's fellowship section, the first group fellowship training began in November 1987, and was attended by four participants from Burma, Algier, Kenya, and Bangladesh. The next group fellowship training is planned for October 1988 to accommodate eight participants.

Dosimetry

The dosimetry unit at Seibersdorf, through the dosimetry section, acts as the central laboratory of the IAEA/World Health Organization (WHO) Network of Secondary Standard Dosimetry Laboratories (SSDLs). Operating since 1976, this network comprises more than 50 SSDLs worldwide; about 40 of which are located in developing Member States. The dosimetry unit maintains secondary standards, provides calibration and reference irradiations to SSDLs and other requesting laboratories, develops newer techniques and instrumentation for secondary standardization, trains fellows, organizes and evaluates dose intercomparison with thermoluminescence dosimeters (TLDs) and ionization chambers, and provides expert services in support of the Agency's technical assistance projects.

As the network's central laboratory, the dosimetry unit is strongly service-oriented and places significant emphasis on training activities.

Two training periods of 2 months each are scheduled yearly to introduce junior scientists of the network to theoretical and practical aspects of standardization of ionizing radiation measurement techniques. Up to four trainees are accepted for each training period and their individually-tailored training plan reflects the state-of-the-art in their home laboratory with respect to calibration work, quality control, and quality assurance.

Training is provided at three levels depending on the educational background and fields of interest of the trainees. The first level includes general training of junior scientists in getting acquainted with various techniques and measuring instruments used in dosimetry. The second level relates to specific calibration/measuring techniques for operators. Advanced training in specific topics of dosimetry is provided to professionals with advanced experience in relevant fields.

Such training includes topics such as:

Ionization chambers. This covers determination of energy dependence of ionization chambers for radiation energies from 10 kV X-ray up to cobalt-60 energy (calibration in air and in phantom); absorbed dose determination by ionization chambers; determination of radiation quality of X-ray beams of low and high intensity by means of Half-Value-Layer measurements; quality control and quality assurance techniques and methods; and performance testing and calibration of protection level monitoring dosimeters.

Thermoluminescence dosimetry (TLD). This covers energy dependence of TLD materials; introduction and demonstration of physical characteristics of TLD (energy dependence, yield, fading characteristics, cleaning and annealing procedures, applicable dose ranges, glow curves); introduction to IAEA/WHO postal dose intercomparison for cobalt-60 and X-ray energies; application of TLD for radiation protection levels (e.g. personal monitoring), therapy level and high-dose dosimetry.

Chemical dosimetry for medium- and high-dose levels. This covers the Fricke dosimetry system; preparation of Fricke solution and evaluation of irradiated dosimeters; the Ethanol-Monochlorobenzene system; and evaluation of irradiated dosimeter ampoules.

Isotope hydrology

The laboratory of the isotope hydrology unit is located at IAEA headquarters in Vienna. The lab participates in technical co-operation projects, research contracts, and in a programme of monitoring isotopes in precipitation as part of a worldwide network.

Services provided by the hydrology unit include isotope analyses of water samples for projects, research contracts, and the network; the storage and distribution of reference and intercomparison materials; assistance with the installation of isotope hydrology laboratories; the development of new standard measurement procedures; the organization of intercomparisons; and training of fellows from developing countries.

Several analytical facilities are now available for on-the-job training:

- System for determination of tritium activity in water samples consisting of electrolytic enrichment facility (two sets of electrolytical cells); liquid scintillation spectrometer; and gas counting facility (two gas proportional counters are available with appropriate electronics).
- System for determination of carbon-14 activity in water samples including the set-up for precipitation of carbonates from water samples; preparation line for converting carbonates into methane; and a low-level gas proportional counting facility.
- Stable isotope ratio mass spectrometry of deuterium, oxygen-18 in water, and carbon-13 in carbonates. At the present time, two mass spectrometers, with corresponding preparation lines, are available for on-the-job training.
- Water chemistry laboratory for carrying out the chemical analyses of water samples (pH, conductivity, anions, trace elements). The laboratory is equipped with an atomic absorption spectrophotometer, an ion liquid chromatograph, and a UV-visible spectrophotometer.

Training is provided at different levels, depending on the background and needs of the trainee. Generally, it covers practical training in preparation of water samples for different kinds of isotope analyses and in operation and maintenance of mass spectrometers, liquid scintillation spectrometers, and gas counters. The fellows also receive basic training in areas such as evaluation and statistical treatment of measurement data, sources of errors in low-level counting systems, and standardization procedures.

Between three to seven fellows per year receive individual training in the isotope hydrology unit. The duration of training varies from 2 weeks to 6 months. In addition, laboratory training in the use of isotope methods in hydrology is provided through the group fellowship training.

An advanced training course in isotope analytical techniques is planned for 1990 and will be addressed to the staff of environmental isotope laboratories in developing countries.