Nuclear Techniques and Isotopes for the Protection of the Environment: IAEA Environment Laboratories Activities in support to Member States

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Nuclear applications for human needs

- Combating cancer
- Improve diagnostic and treatment of diseases
- Promote food security and sustainable economic development
- Understand and protect the environment
- Improve quality and availability of water
- Provide knowledge and expertise for sciences and industrial applications
As the 1\textsuperscript{er} of January 2010, IAEA has restructured its Environment Program that is entirely managed under the Division in Monaco. The "Environment Laboratories" as renamed consists of the Marine Environment Laboratories in Monaco and the Terrestrial Environment Laboratory located at Seibersdorf in Austria.
Programmatic priorities

• To support IAEA MSs to develop monitoring programmes of environmental ecosystems (radionuclides, inorganics and organics)
• To improve knowledge of the behaviour and fate of pollutants with emphasis on marine biosphere impact and land/coastal zone
• Production of Reference Materials
Short & Long term priorities

• Short term
  • Reinforce exchange of data and expertise in Member States also in terms Quality Assurance/Quality Control

• Long term
  • Collate and harmonise the existing data basis as well as monitoring programmes in Member States by reinforcing networking and collaborations with other UN agencies, national and international organizations.
  • Consider the socio-economic impact of climate change for a sustainable environment
Understanding the environment applying isotopic and nuclear techniques

Nuclides and isotopes can be used as a tool
• to study marine and coastal processes in time and space;
• to trace water masses and connected transboundary pollution over hundreds of km;
• to study pollution and its temporal evolution in coastal areas;
• to recognise and identify polluters by its typical isotopic pattern;
• to contribute to climate change studies;
• ... etc. (radionuclides have a clock inside);
• to conduct radioecological studies and assessments;
• to contribute for the production of reference materials;
• to develop analytical methodologies.
ISOTOPES: A POWERFUL TOOL

• Isotopic composition in nature
  - may be stabilised
  - may be changing
    * radioactive decay of parent element
    * fractionation due to natural processes
    * fractionation due to human activities

• Therefore, e.g. isotopic composition varies depending on the environmental compartment
  - Isotopes used as tracers to understand processes (environment, medicine etc.)
  - Isotopic signature used to apportion sources, for authentication purposes etc.

• Isotopes: manipulations and applications
  - element content determination (isotope dilution)
  - isotopic enrichment (production of isotopic certified reference materials)
  - industrial, military etc. applications (nuclear reactions, nuclear material accounting)
  - medical treatment etc. applications (radioactivity)
Management of Terrestrial Environment

Radioecological studies and assessments

Pb-210, Cs-137

• Soil erosion studies
• Lake sedimentation studies
• New tracers (Ra, Th, stable Pb isotopes)
Air quality management

Radioecological studies and assessments

Airborne alpha and gamma spectrometry
- XRF, neutron activation analysis
- Atmospheric mixing (Rn-222, Be-7)
- Pollution residence time estimates
  (Pb-210/Bi-210/Po-210)
Nuclear techniques for understanding and protecting terrestrial and aquatic environments

Guidance documents on environmental assessment and remediation:

✓ TRS472
✓ TECDOC 1616
✓ TECDOC 1675

Direct support Member states in radioactivity transfer studies and remediation planning

✓ Chernobyl affected areas
   (Belarus, Russia, Ukraine)
✓ Semipalatinsk test site
✓ Kuwait and many others
APPLICATIONS OF BIOMARKERS AND STABLE CARBON ISOTOPES IN THE ENVIRONMENT

• Diagnosing and fingerprinting pollution (e.g. oil spills)
• Assessing origin of compounds (from land-based and/or marine sources)
• Investigate cycling and behaviour
• Providing variations in productivity levels in the water column
• Distinguishing and tracing different food sources
• Interpreting past ecosystems by reconstructing paleoproductivity, terrigenous input and anthropogenic impacts as and indicator of global change
Distribution of δ13C in the Environment

- Anthropogenic CO2 (urban area): -7.8 to -12‰
- Atmospheric CO2 (rural area): -7.8‰
- Seagrasses: -10‰
- Macroalgae: -15‰
- Phytoplankton: -22‰
- Zooplankton: -20‰
- Vertebrates: -17‰
- DIC: 0‰
- DOC: -23‰
- CH4: -75‰
- Sediment: -22‰
- Carbonate: 0‰

- Fossil fuels:
  - Coal: -25‰
  - Natural gas: -40‰
  - Petroleum: -30‰
Stable carbon isotope compositions are used to fingerprint, identify and trace the source of the oil spills.

US PUI Project: Implementation of a comprehensive sampling and analytical methodology to determine and trace oil pollution in marine waters (2011-2012)
Tracing Different Food Sources

Stable carbon isotope compositions of lipid biomarkers are used to understand interactions/exchanges between the animal tissues and their symbiotic algae in corals, tracing their food sources and their mode of nutrition.
Specific lipid biomarkers and their stable carbon isotope compositions are used to reconstruct the different carbon sources (marine, terrestrial, ...), and e.g. sea ice conditions.
ICP-MS, a Flexible Tool

ICP-MS technique has two different applications in the earth and environmental sciences:

• Measurements of isotopic composition
• Measurement of element concentration (monitoring studies)
Aquatic and Terrestrial Ecosystems Isotopes in the Assessment and Monitoring

- Estimate **pollutant loads** from land based sources in receiving coastal and marine waters
- Support **monitoring** of coastal and marine waters
- Determine **major sectors** of activities contributing to release of pollutants
New Developments and Progress in the Environmental Pollution Studies

Isotopic compositions are used to fingerprint, identify and trace the source of pollution.
Isotopes to understand processes and their relative contributions

Source picture: P. Taylor, EC JRC IRMM.
Isotopes to authenticate the geographical/climatic origin of food

Multi-elemental analysis $n(^{87}\text{Sr})/n(^{86}\text{Sr}), d^{13}\text{C}, d^{18}\text{O}, d^{15}\text{N}$

Food Origine Mapping

Enabling Analytical Excellence
Provision of Reference Products for the environment and laboratory performance support

The IAEA NAEL assists laboratories to maintain their readiness by:

- 110 reference materials (RM) available
- Major supplier worldwide (stable isotopes / radionuclides)
- Proficiency tests – interlaboratory comparisons
- Preparation of recommended analytical methods for radionuclides,
- Training – Analytical advice – QA/QC
Provision of Reference Products for the environment and laboratory performance support

110 reference materials (RM) available for radionuclides, stable isotopes, trace elements and organic contaminants
Provision of Marine RMs, Interlaboratory Comparison Exercises and High Precision Analyses

Marine reference materials (RM) for trace elements, organomercury and organic contaminants.

Global inter-laboratory comparison exercises and proficiency tests for the benefit of MS laboratories (quality control).

High resolution ICP-mass spectrometry for trace elements, metal speciation and long-lived radionuclides.

Analytical developments for compound specific isotope analyses (CSIA).
Support Capacity Building of Member States to Protect the Marine Environment

Training on analytical techniques for trace elements, organic contaminants and organometals

Reference methods for marine environmental studies

Environmental surveys on behalf of UNEP Regional Seas Programmes (Black Sea, Caspian Sea, ROPME)
Understand radioactivity in the oceans and seas
Understand radioactivity in the oceans and seas

- Okhotsk
- Sea of Japan
- Mururoa Fangataufa
- Thule
- Irish Sea
- N E Atlantic dump site
- Kara Sea
- Barents Sea
- Baltic Sea
- Black Sea
- Caspian Sea
- Mediterranean Sea
- Mediterranean
- GEOTRACES
- Irish Sea
- Irish
- South Hemisphere Ocean Tracer Survey

Environment Laboratories
Monaco & Seibersdorf
On-line access to world-wide marine radioactivity data

- 110,000 data
- 94 radionuclides
- 30 years
- 339 laboratories

http://maris.iaea.org/
Understand radioactivity in the oceans and seas

Underground laboratory
Diagnostic of pollution in marine ecosystems
Diagnostic of pollution in marine ecosystems
Ocean Carbon and Climate Change
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Ocean Acidification

- The oceans absorb one fourth of the CO2 emitted into the atmosphere from human activities. As this dissolves in seawater, it forms carbonic acid, increasing marine acidity. Then provoking the so called phenomenon of Ocean Acidification that has an impact on the reproduction of the marine life and on the physiology of the marine organisms.
Ocean Acidification

Impact of Ocean Acidification on human economy

TOURISM

- Biodiversity
- Economic valuation
- Policy perspectives
- Social welfare

FISHERIES AND AQUACULTURE
Network of “Analytical Laboratories for Measurement of Environmental Radioactivity” (ALMERA)

• Mission: analytical support for the Agency's activities in the radiological assessment of areas affected by the accidental or intentional release of radioactivity (will be revised soon),

• Providing accurate and timely radionuclide results in support of IAEA projects (125 laboratories)

• Acting as source of reliable and consistent information and advice for government bodies