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COMMISSION OF NUCLEAR SCIENCE AND APPLICATION  
DEPARTMENT OF RESEARCH AND INFORMATION  
LABORATORIES

***CABILITIES AND ACTIVITIES***

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Amman- Jordan  
November 4, 2014

LABORATORIES



GAMMA SPECTROSCOPY LABORATORY

The main task of the laboratory is the measurement of radioisotopes from different sample matrices (soil, food, filters, water ) for the purposes of measuring gamma emitters. The average through output of the laboratory is about 40 samples per day for uranium exploration project, 15 sample per day from export and import product in addition to the samples for environmental monitoring and research.

For the purpose of measurements different spectroscopy systems are used:

- System with 15% HPGe detector from Canberra
- System with 40% HPGe detector from Canberra
- System with 20% HPGe detector from Canberra
- System with 50% HPGe detector with 42 sample changer from Ortec
- In addition to several portable systems for field measurements

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INTRODUCTION



The research of the department is primarily based on competences in radiation physics, radiation chemistry, analytical chemistry radioecology, and nuclear measurement techniques and methods.

The research and development work of the department is carried out in close co-operation with Jordanian universities and research institutes . The department participates in national and international research programmes including the IAEA research programmes and the USA DOE Research Programme.

The department organization include the following scientific aspects :

- Radiation Physics (Gamma spectroscopy, Radon measurements and neutron activation)
- Radiation Chemistry ( Alpha spectroscopy, beta counting, gross alpha/beta and isotopes separation and extraction)
- Dosimetry ( personnel and industrial dosimetry, SSDL).
- Analytical Chemistry ( ICP-MS, ICP-OES, TXRF, Titration and FTIR measurement technique).

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**LABORATORIES**



**PERSONAL DOSIMETRY LABORATORY (PDL)**

Provide radiation protection services to the 2325 radiation workers in 160 hospitals and different national institutes and companies using:



- Total body dosimeters.
- Finger dosimeters.
- Neutron dosimeters.
- Pocket dosimeters.



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**LABORATORIES**

**Radiochemistry laboratory**

The main task of the laboratory is the separation of radioisotopes from different sample matrices (soil, food, filters, water ) for the purposes of measuring alpha and beta emitters such as:  
(U-238,234, Pu-238,239, Am-241, Sr-90, Po-210)

The services provided by this laboratory are as following:

- Preparation of more than 150 imported food samples yearly.
- Preparation of 50 milk samples for export
- Preparation of more than 100 samples monthly (soil, food, milk, water, grass, leaves and air filters) for environmental monitoring inside and out side the location of research reactor .
- Preparation of 120 samples from the gulf of Aqaba for determination of sedimentation rate , contamination from heavy shipments and .industry

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**LABORATORIES**

**Secondary standard Calibration laboratory. (SSDL)**


Provide calibration services for more than 20 company and institutes from public and privet sector where they used radiation measurement devices such as:

- Survey meters.
- Radiation gages and NDT at industry
- Ionization chambers and dose calibrators at the hospitals.


The laboratory is equipped with All the necessary tools, phantoms and devices for providing quality control services to the hospitals in the field of radio diagnostic Radio therapy, nuclear medicine and Mammography .



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The process in the Analytical Chemistry Lab. Is as following


Chemical Sample Preparation.




Clean room and final Preparation.



Measurements by ICP-OES or/and ICP-MS




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**LABORATORIES**

Analytical chemistry laboratory

ICP-MS & ICP-OES




ICP-MS and ICP-OES can be used for a wide variety of Applications

- Environmental
- Metallurgical
- Biological
- Petrochemical
- Geological
- Clinical
- Semiconductor industry

Using the ICP technique up to 75 elements can be measured with concentrations down to 1 part per trillion.

The laboratory was established at the second half of the year 2010 and used for measurement of more than 1000 samples for JERI company and 20 samples for RIO Tinto company and 70 samples per day for JUMCO in addition to the several hundreds PT, check, research and environmental samples .For the last year the number of measurements exceeded 20000 samples for uranium exploration project



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**LABORATORIES**

**Physical Sample Preparation Laboratory**

```

    graph TD
      Log[log] --> Drying[Drying]
      Drying --> Moisture[Moisture content]
      Drying --> Grinding[Grinding]
      Grinding --> Sieving[Sieving]
  
```

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**LABORATORIES**

**Alpha / Beta spectrometry and gross alpha / beta laboratory.**

The laboratory was used to measure more than 500 food and water samples prepared by radiochemistry in addition to international PT samples

The laboratory develop a rapid and economic method for direct extraction and measurements of uranium using the Liquid Scintillation Counter with 360 sample capacity autosampler.

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### Neutron Applications:

- Neutron Shielding.
- Fast Neutron Spectroscopy.
- Slow Neutron Spectroscopy.
- Calibration of neutron Survey Meters.
- Irradiation of neutron personal dose monitors (TLD's).
- Delayed Neutron Activation Analysis (DNAA).
- Prompt Gamma Neutron Activation Analysis (PGNAA).


### Neutron Lab Achievements:

- Build Shielding Houser for Cf-252 neutron source.
- Build In-House control system for safe handling of the neutron source.
- Prepare shielding materials to make neutron shielding and moderation experiments.
- Provide 8 weeks training for students from nuclear engineering section at JUST.
- Provide facility for neutron laboratory for students from nuclear engineering section at JUST.
- Help students from nuclear engineering section at JUST make Graduation Projects (Neutron Shielding and Neutron Dosimetry).

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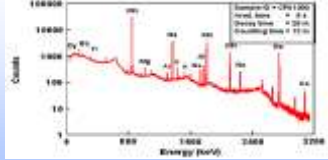


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Neutron activation laboratory


Neutron-Shield System	Control and Monitoring Systems	Neutron Shielding Materials	
			
Gamma Spectrum of Neutron Activated Sample			
		Fast Neutron Detector	Neutron Dose Measurement
			

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## LABORATORIES

### Polymers laboratory




The laboratory is equipped with different tools and devices for testing the physical and mechanical characteristics of polymer materials and is used for research and study the effects of radiation to improve these characteristics. The laboratory was used from several researchers and PhD students from Jordan Un. , Al-Albeet Un. And Al-Yarmuk Un. Also the laboratory was used to design and create a modules for moderators and attenuators for neutron activation analysis.


Impactor




Melt Flow Tester




Melt Flow Tester




Sample Preparation



Tensile




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## LABORATORIES

### Nuclear instrumentation and training laboratory



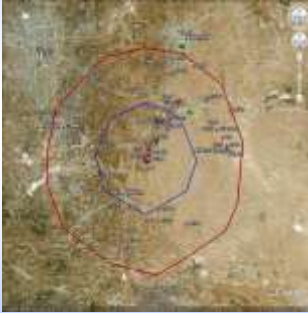
1. **Nuclear instrumentation workshop:**  
The workshop provide preventive and maintenance services and electronic calibration for all laboratory using very sophisticated tools and test devices .  
The workshop design and implement several tools , devices and upgrades used in different laboratories. As an example
  - Upgrade the auto sampler for gamma system from 16 samples to 42 samples including the software, the sample holder and sample tray
  - Upgrade the autosampler for ICP-OES to hold and manipulate 50 mL samples instead of 10 mL samples
  - Design and implement a tool for Po-210 measurements.
2. **Training:**
  - Establishment of a routine course on radiation protection first level for radiation workers from public and privet sectors
  - Provide a specialize courses on different aspects of radiation measurements by request
  - For the last three years we provide 8 weeks training for the students from nuclear engineering section at JUST Un. In addition to the once a week exercise using NA facilities during the semester.
  - For the recent year we provide fellowship training for 8 fellows from Palestine , Iraq and Yemen for duration of two to three months through IAEA
  - Provide training for B.Sc and M.Sc students from different national Un's.

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**ERM program for JRTR (cont.)**

- **Sampling** **90 locations**
  - Air monitoring stations – 3 locations;
  - Rain collectors – 3 locations;
  - Monitoring area – 10 km radius around JRTR
- **Sample preparation methods** **about 1100/year**
  - dryings; evaporations
  - Crushing
  - Milling
  - Ashing
  - Freeze drying
  - digestion
  - simple distillations
- **Measurements** **about 2500/year**
  - gamma spectrometry
  - H-3 and Sr-90
  - gross beta
  - gross alpha



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**ERM program for JRTR**

- The Environmental Radioactivity Monitoring Program at JRTR was started in January 2011.
- During the last two years RID directorate at JAEC perform a Preoperational Monitoring Program to establish the reference levels for evaluating the impact of the JRTR during operation.

The major components of the Environmental Monitoring Program are:

1. Monitoring locations;
2. Environmental media;
3. Specific nuclides;
4. Monitoring frequency;
5. Analytical frequency;
6. Operating Procedures, Quality Assurance Program;
7. Reporting of Environmental Radioactivity Monitoring Program data and estimated doses for public, both to the JRTR center and the regulatory bodies.

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**ERM program for JRTR (cont.)**


**Sampling and Analysis methods**

Object of survey		Sampling method	Analysis item	Analysis method
Air	Particulate	Continuous arresting air larger than 300 m <sup>3</sup> per week in the fiberglass filter paper with air sampler	Entire beta Gamma isotopes	The filter paper is collected on a weekly basis, and the low-level alpha/beta gauge makes measurement after 72 hours for natural attenuation of radon series. The filter paper is collected on a monthly basis and gamma isotope is measured by the gamma nuclide analyzer.
	Radioactive iodine	Continuous arresting air larger than 300 m <sup>3</sup> per week in the active carbon cartridge with air sampler	<sup>131</sup> I	Recollecting the active carbon filter on a weekly basis and measuring the iodine with the gamma nuclide analyzer
Water	Drinking water ( Underground water) / Surface water / Rainwater	Sampling necessary volume with proper sampling tool	Entire beta	Collecting 500 ml, evaporating and concentrating, placing on the dish for instrumentation, drying with infrared dryer, and then measuring with low-level alpha-beta counter. Instrumentation 72 hours after specimen sampling
			Gamma isotopes	- Drinking water, underground water and rainwater: Evaporating and concentrating 3 - 5 l, and directly measuring with the gamma nuclide analyzer. Ground water: Evaporating and concentrating 20l, and measuring with the gamma nuclide analyzer
Surface soil		Sampling approx. 2 kg of surface soil (0 - 5 cm) from five locations within 5 m from sampling points with same ratio	Gamma isotopes	Drying, crushing and then screening with sieve with eye smaller than 1 mm, placing on 450 ml instrumentation vessel, and then measuring with the gamma nuclide analyzer
Milk		Sampling approx. 10 l of raw milk at stock farm	Gamma isotopes <sup>131</sup> I	Placing in 2 lx marionelli vessel, and then measuring with the gamma nuclide analyzer. When failing in satisfying the detection target, evaporating and drying defined volume, and then measuring with the gamma nuclide analyzer
Farm product (e.g., cabbage, radish)		Sampling 4 kg or more at the field	Gamma isotopes	Drying, crushing, placing on 450 ml instrumentation vessel, and then measuring with the gamma nuclide analyzer
Terrestrial living beings (e.g., pine and olive leaves)		Sampling 5 kg or more within 10 m from the sampling point	Gamma isotopes	Same as farm products
Radiation		Environmental radiation monitor (ERMS)	Gamma dose rate	The argon gas compressed chamber is used for measuring gamma dose rate at height of 1 m above the ground to store five-minute's average data in the server, and to use one-hour's average data.
		Thermoluminescence dosimeter (TLD)	Collective gamma dose	Three TLD devices are installed on each TLD housing at a height of 1 m above the ground, and recollected and measured every three months.


**ERM program for JRTR (cont.)**

**Sample type, Sampling frequency and number of sampling points**

Class	Sample	Frequency	Nuclide	Number of sampling point	
				Off-site	On-site
Radiation	Environment Radiation	Continuously (Fixed ERM)	Gamma dose rate	1	2
		Monthly (portable ERM)	Gamma dose rate	10	4
		Quarterly (TLD)	Cumulative dose	18	8
Radioactivity	Air particulate	Monthly	Gamma-emitter	1	2
		Weekly	Gross beta	1	2
	Air moisture	Monthly	<sup>3</sup> H	1	2
	Air iodine	Weekly	Iodine-131	1	2
	Surface soil	Semiannually	Gamma-emitter	10	4
		Quarterly	Gamma-emitter	1	2
	Biological Indicator	Semiannually	Gamma-emitter	2	2
	Surface water	Monthly	Gamma-emitter	1	1
			Gross beta, <sup>3</sup> H	1	1
	Underground water	Quarterly	Gamma-emitter	1	1
			<sup>3</sup> H	1	2
	Rain water	Monthly	Gamma-emitter	1	-
Gross beta			2	-	
<sup>3</sup> H			2	-	
Vegetation			2	-	
fruit			2	-	



## QA/QC and Performance Evaluation Results.



The laboratories follow a quality control procedures for monitoring the validity of tests and calibrations undertaken.

- ✚ The accuracy and reproducibility of measurement systems were verified on a periodic basis
- ✚ **regular use of certified reference materials and/or internal quality control using secondary reference materials;**
- ✚ Participation in **interlaboratory comparison and proficiency-testing programmes** with good results.
- ✚ **replicate tests** and calibrations.

Intercomparison measurements and proficiency tests are the best mechanisms to show overall performance of the laboratory work

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## ERM program for JRTR (cont.)



### Analyzed Radionuclides

Object of survey	Nuclide to analyze			Purpose of analysis
	Nuclide to monitor	Reference nuclide	Natural nuclide	
Air	Whole β, <sup>131</sup> I, <sup>137</sup> Cs, <sup>137</sup> Cs, <sup>60</sup> Co	<sup>106</sup> Ru, <sup>144</sup> Ce	<sup>7</sup> Be	Assessment of dose by inhalation
Drinking water (Underground water)	<sup>3</sup> H, <sup>3</sup> H	<sup>137</sup> Cs, <sup>60</sup> Co, <sup>137</sup> Cs	-	Assessment of dose by ingestion
Surface water	whole β, <sup>3</sup> H, <sup>131</sup> I, <sup>137</sup> Cs, <sup>60</sup> Co, <sup>137</sup> Cs	-	-	Identifying radioactivity level
Rainwater	whole β, <sup>131</sup> I, <sup>3</sup> H	<sup>137</sup> Cs, <sup>60</sup> Co, <sup>137</sup> Cs	-	Identifying radioactivity level
Surface soil	<sup>137</sup> Cs, <sup>137</sup> Cs, <sup>60</sup> Co, <sup>90</sup> Sr	<sup>90</sup> Co, <sup>54</sup> Mn, <sup>106</sup> Ru, <sup>144</sup> Ce	<sup>40</sup> K	Understanding accumulation trend
Milk	<sup>137</sup> Cs, <sup>131</sup> I, <sup>90</sup> Sr	<sup>106</sup> Ru, <sup>144</sup> Ce	<sup>40</sup> K	Assessment of dose by ingestion
Farm product (e.g., cabbage, radish)	<sup>137</sup> Cs, <sup>60</sup> Co, <sup>60</sup> Co, <sup>54</sup> Mn	<sup>131</sup> I, <sup>106</sup> Ru, <sup>144</sup> Ce	<sup>40</sup> K	Assessment of dose by ingestion
Terrestrial living beings (e.g., pine and olive leaves)	<sup>131</sup> I, <sup>137</sup> Cs, <sup>137</sup> Cs, <sup>60</sup> Co	<sup>106</sup> Ru, <sup>144</sup> Ce	<sup>7</sup> Be, <sup>40</sup> K	Understanding accumulation trend
Fallout	whole β, gamma emitters	-	-	Identifying radioactivity level

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QA/QC and Performance Evaluation Results.

1. Proficiency Testing (PT)

The laboratories participated yearly in several PT programs (USA MAPEP , International ALEMERA network and IAEA programs).

The results from these tests put our laboratories in advanced position between hundreds of the word wide laboratories regarding the number of measured elements and the accepted results.

In addition to that our laboratories was accepted as a member of ALMERA network for the emergency situations in the word as we participate in determination and identification of contaminants after Fukushima accident and we participate in international meeting for decision of the results and our results were in a very good correlation with international results.



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Performance Evaluation Results

3. ISO 17025 Accreditation







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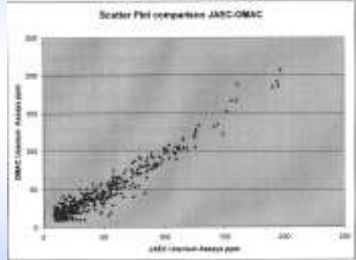


Performance Evaluation Results

2. Inter-Laboratory Comparison



- The results from measurements of 482 samples in duplicate (350 pore hole samples and 132 bulk trench samples) for RIO Tinto company indicate a very good correlation between our results and OMAC laboratory results



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