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Neutron Activation Analysis Lab at ETRR-2: Achievements, future plans, and collaboration opportunities

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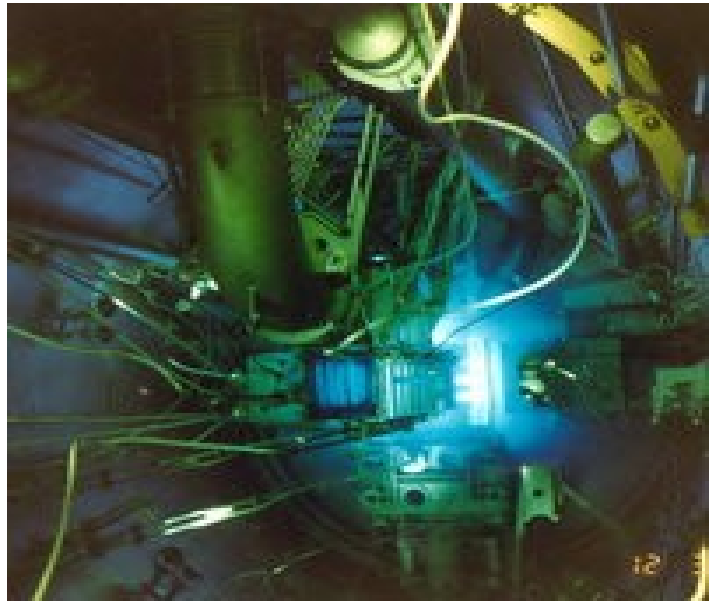
Egyptian Atomic Energy Authority

Outlines

1. Brief description of ETRR-2
2. Overview on NAA Lab
    - HPGe
    - Irradiation facilities
2. Services and routine tasks
3. Research works
4. Future plans
5. Collaboration opportunities

1- Egypt Second Research Reactor (ETRR-2)…



- Owned and operated by Egyptian Atomic Energy Authority
- 60 km north of Cairo.
- Open pool multi-purpose rector.
- 22 MW.
- 1st criticality November 27th 1997
- Max. thermal neutron flux of 2.7 x 10^{14} $cm^{-2}s^{-1}$.
- Cooled and moderated with light H_2O
- Be reflector.

ETRR-2 utilizations…..

- Training and Educational purposes.
- Radioisotopes production:

  Medical:

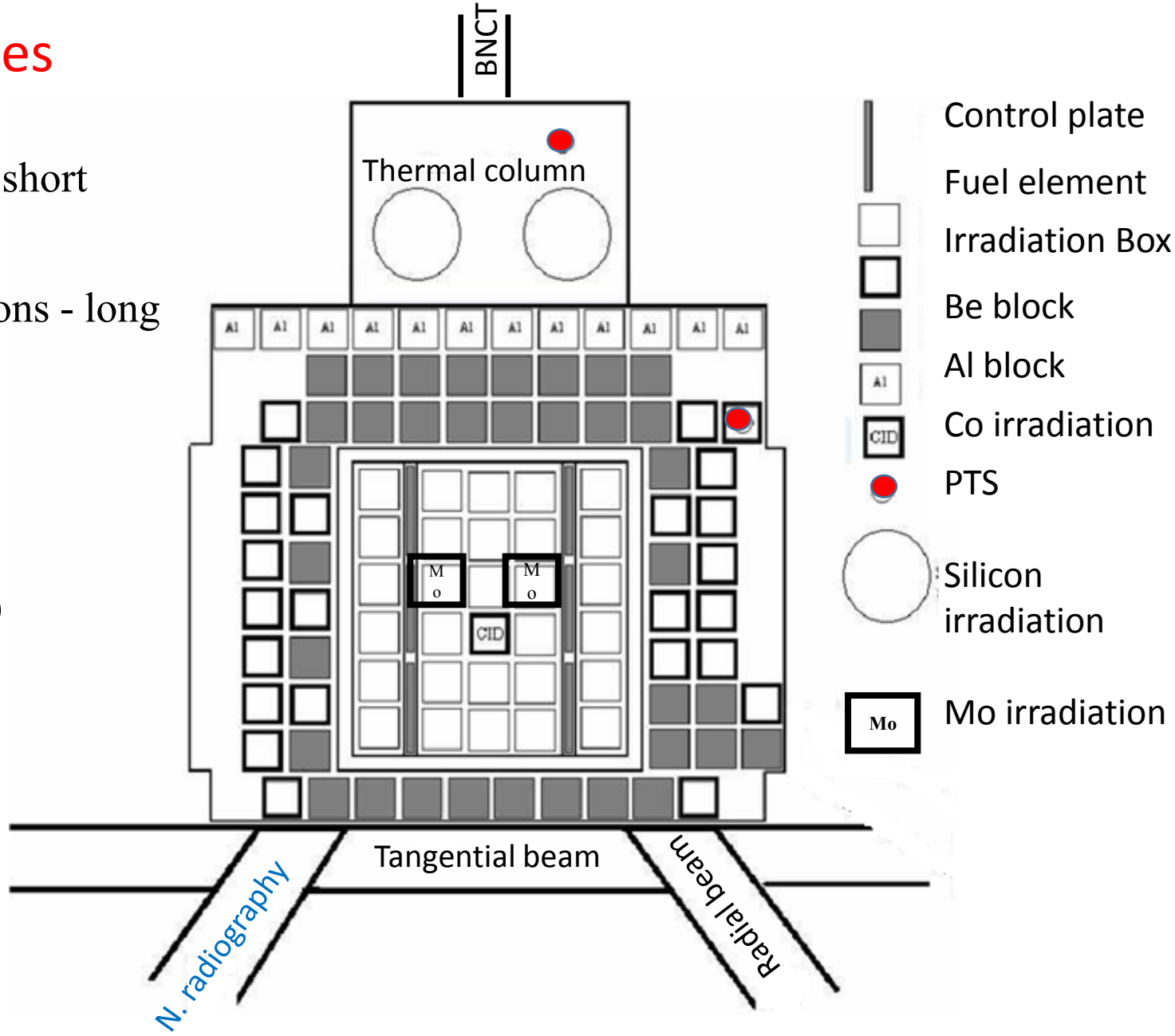
  - ^{99}Mo, and ^{131}I from LEU targets.
  - ^{99}Mo/^{99m}Tc generator,
  - ^{125}I from Xe (gas) targets
  - ^{192}Ir – for brachytherapy

  Industrial

  - ^{60}Co – tiny beads for well-logging
  - ^{192}Ir – for gamma camera
  - Calibration and radiotracer sources
- Si doping
- (Under-water) Neutron Radiography
- Gem stone coloration
- Neutron Activation Analysis (NAA)

Irradiation facilities and beam tubes

- Two pneumatic transport systems (PTS) – short irradiation
- Several manually loaded irradiation positions - long irradiation
- Five beam tubes
- Co-60 irradiation facility
- Two Mo irradiation positions (LEU target)
- Two 6-inches silicon doping facility



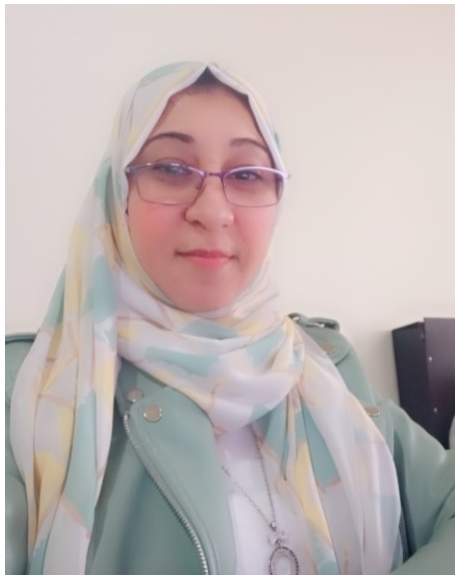
N. Diffractometer (proposed)

2- NAA Laboratory

Lab team

Nader Mohamed
(the God father)

Mohamed Soliman



Fatma Salah

Abdullah Metwally

Mohamed Shabib

Raghda Ahmed

NAA Lab Description - HPGe

- Three p-type HPGe detectors (one of them is a portable detector).
- One n-type HPGe detector with Compton suppression system – 750 suppression ratio

  (All detectors are 100% relative efficiency and 2.1 keV resolution at 1.33 MeV Co-60 line)
- For PGNAA, one n-type HPGe, Canberra, 25% relative efficiency.

For calibration

- Point sources (Eu-152, Co-60, Ba-133, and Cs-137)
- MCNP simulation

Lab Description - PTSs

- Short irradiation schemes (up to 15 min.)
- 1 second transfer time

Site #1 installed near the reactor core.

Thermal flux: 4.2 x 10^{12} $cm^{-2}s^{-1}$.

Site #2 installed in the thermal column, well thermalized neutrons.

Thermal flux: 3.3 x 10^{11} $cm^{-2}s^{-1}$.

PTS

PE capsules

PE Rabbit

Lab Description – long irradiations

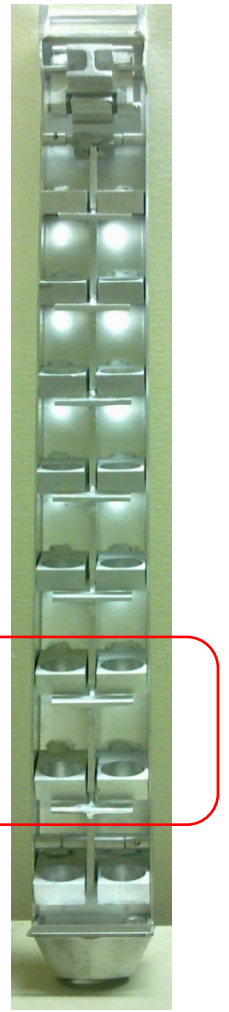
Irradiation grid - Manually loaded

Up to few hours

Thermal Flux: max. 1.6 x 10^{14} $cm^{-2}s^{-1}$

PE capsules

Al can



Sample holder

Sample holder: 16 irradiation Al cans arranged in 8 shells.

Each Al can are filled with up to 12 PE capsules.

3- Services and Routine Tasks

- Providing elemental analysis services for research institutes and universities.
- Analysis of natural radioactivity in environmental and foodstuff samples
- Training for students and fellows.
- Analysis of reactor coolant and radioactive waste.
- Measuring the induced radioactivities in irradiated gemstones to meet the transportation requirements (must be < 74Bq/g).
- Production of weak radioactive sources
    - Calibration
    - Well-logging in oil industry

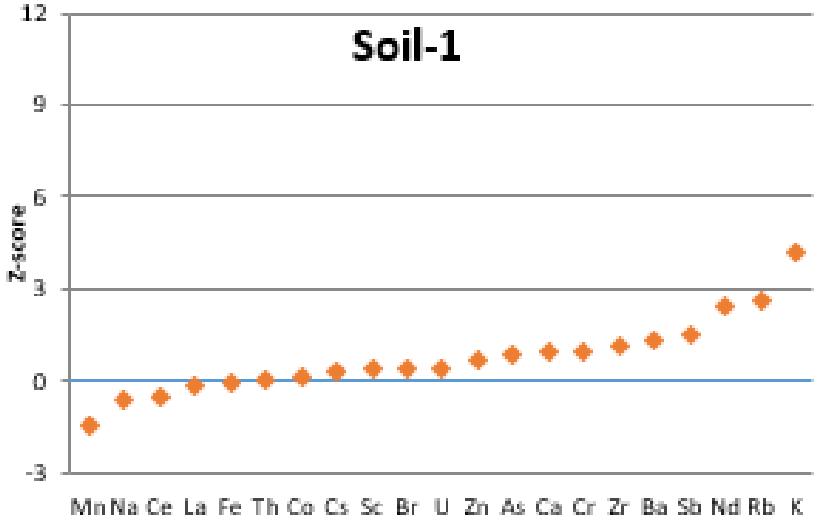
3- Research Activities

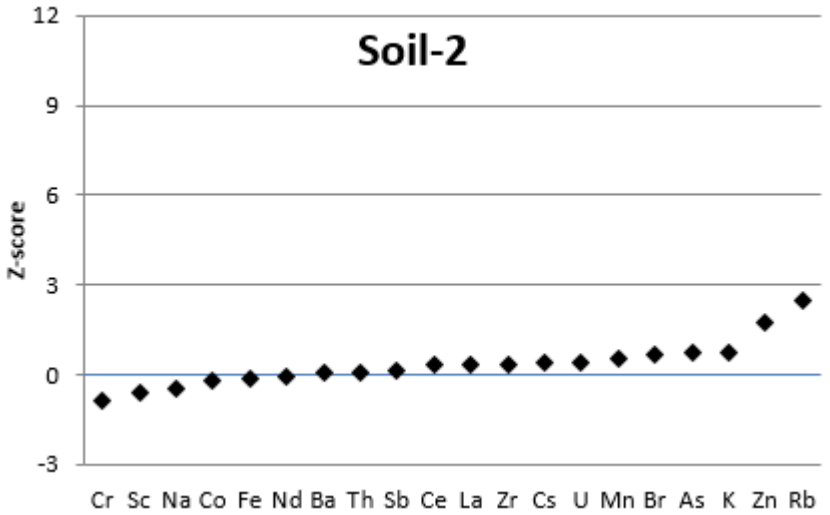
- Large Sample INAA.
- Automation of INAA.
- Elemental analysis - economic minerals, geological, biological, food, and environmental samples
- Environmental radioactivity.
- Standardization of NAA – k_0-method

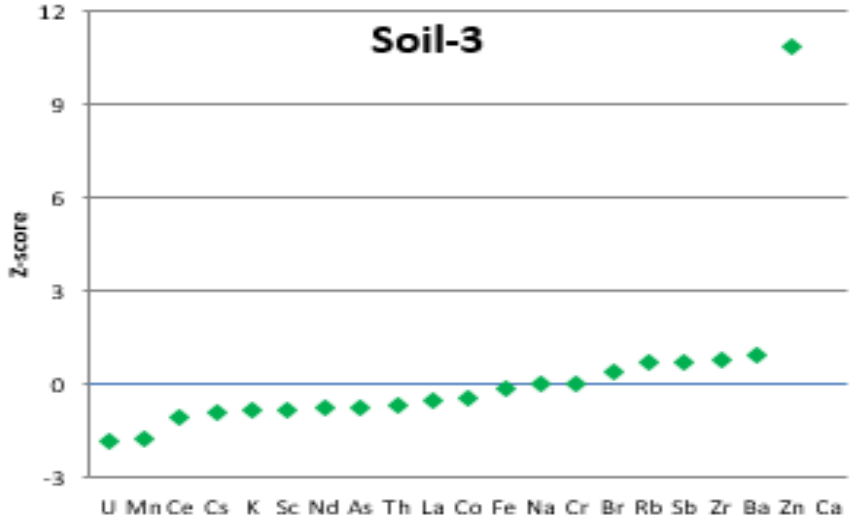
- **Flowing Sample Neutron Activation Analysis (FSNAA).**
- **Determination of Trace Elements in Medical Plants and Their Infusions.**

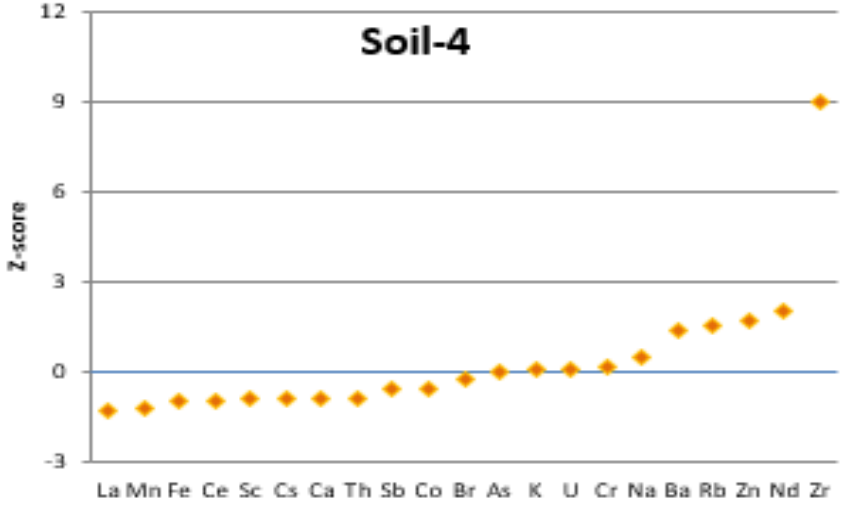
3.1 Performance assessment-

- Analysis of quality control material
- Participation in proficiency tests

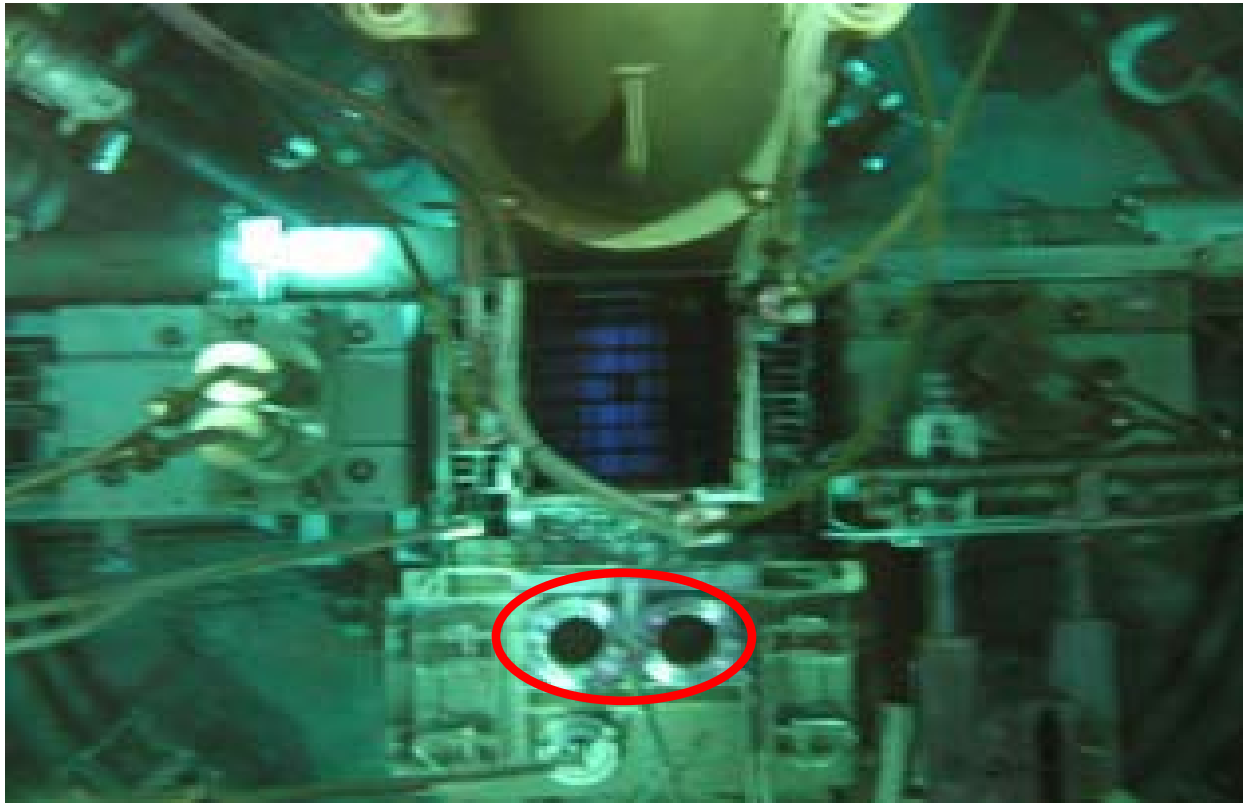








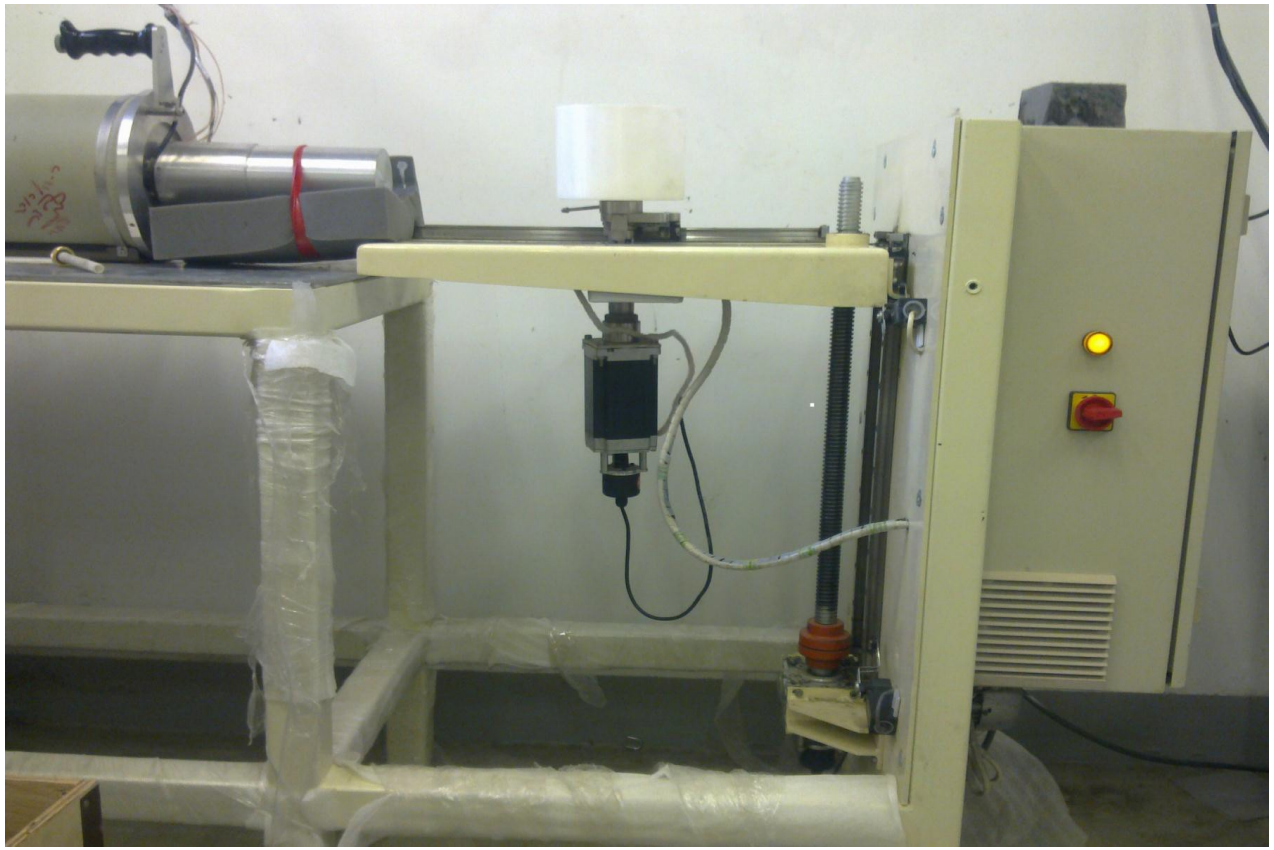
3.2 Large Sample NAA



Irradiation facility

IAEA CRP1499 on “Application of Large Sample Neutron Activation Analysis Techniques for Inhomogeneous Bulk Archaeological Samples and Large Objects 2008-2012”

3-2 Large Sample NAA



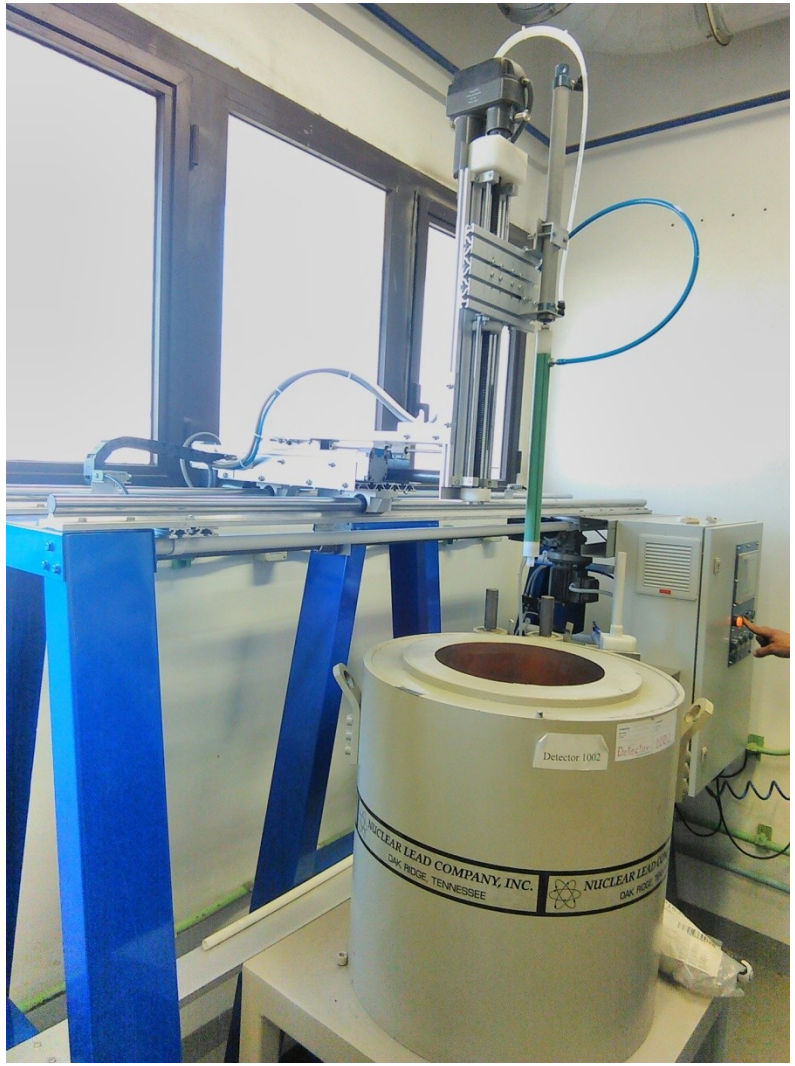
Counting System for LS-NAA

IAEA CRP1499 on “Application of Large Sample Neutron Activation Analysis Techniques for Inhomogeneous Bulk Archaeological Samples and Large Objects 2008-2012”

3.3 Automation of INAA

Sample changer has been designed and installed to increase the Lab throughout.

Challenges: Motors noises affect the performance of amplifiers.



IAEA-CRP 1888 “Development of an Integrated Approach to Routine Automation of Neutron Activation Analysis 2012-2016”

3.4 Health-Related Studies.

1- Studying the concentration of some selected trace elements in the patients with confirmed Breast Cancer.

It was found that Se, Zn and Cr elements from the malignant tissues are significantly elevated compared to the normal tissue.

The difference in the concentration of trace elements indicates the possibility of using these elements as discriminator factor.

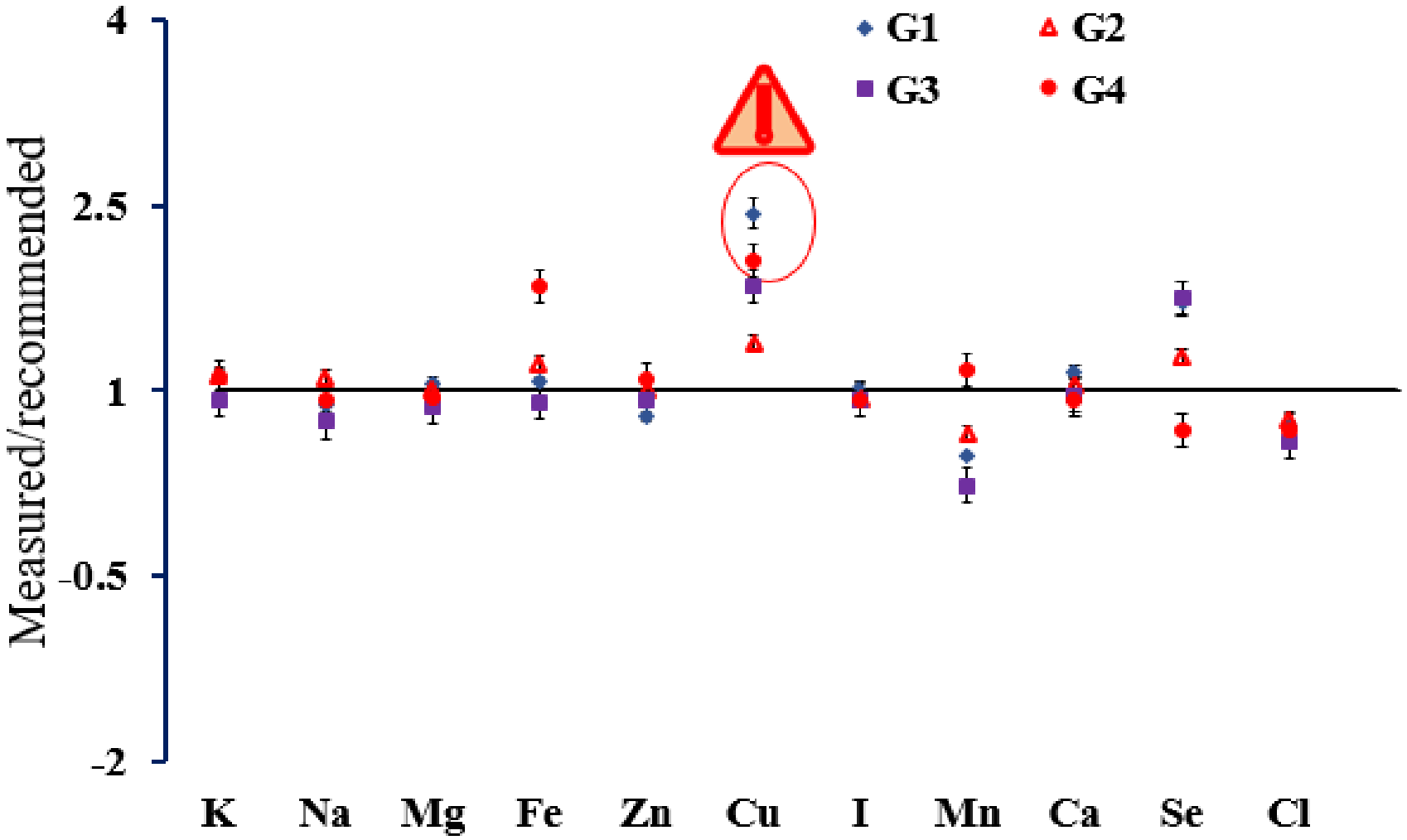
(the project was supported by Arab Atomic Energy Authority)

2- Investigation of the human stones (kidney, liver,…) using NAA and other tools.

(Thesis of M.Sc student)

3- Determination of trace elements in infant milk powders available in the local market

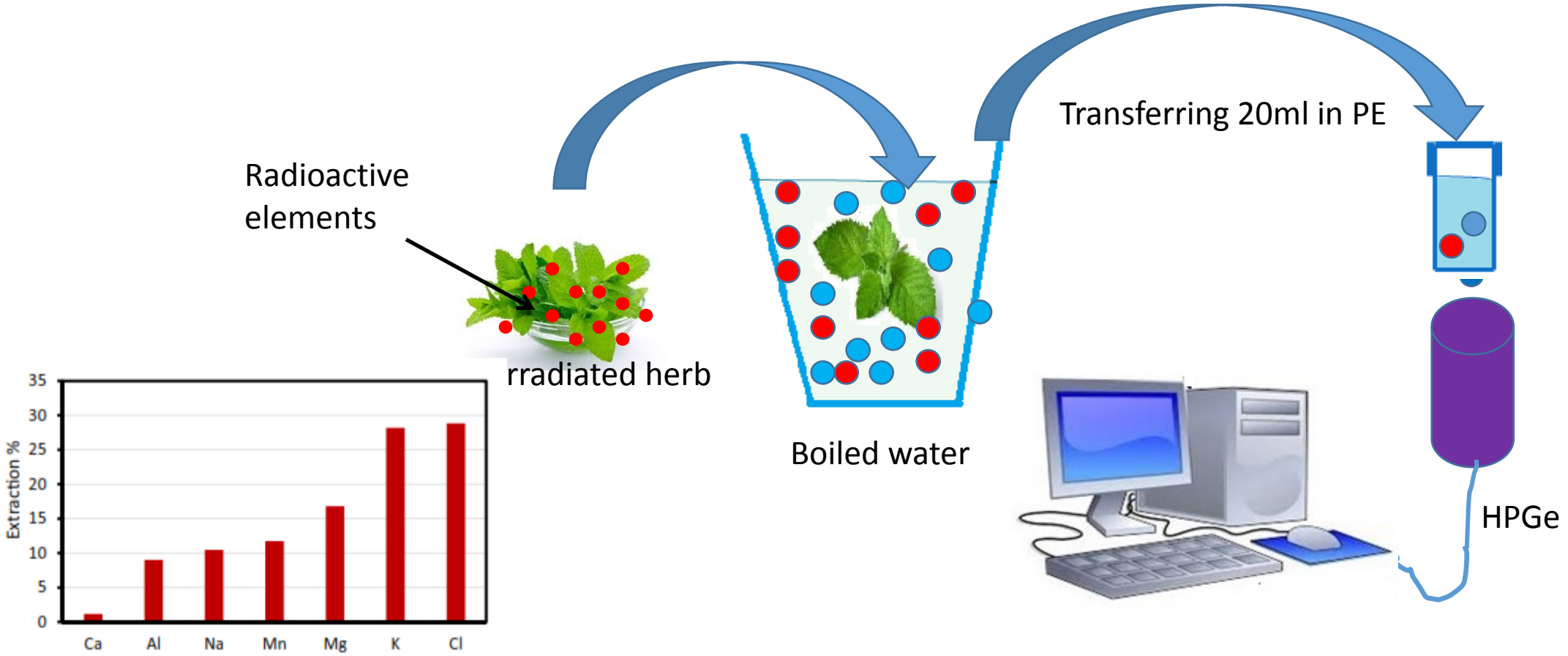
Ratios between measured and recommended concentration levels
G1: 0-6 months,
G2: 6-12 months,
G3: 0-12 months,
G4: 1-3 years



Infants' formula are a suitable source of nutrient for infants during their early life stages.

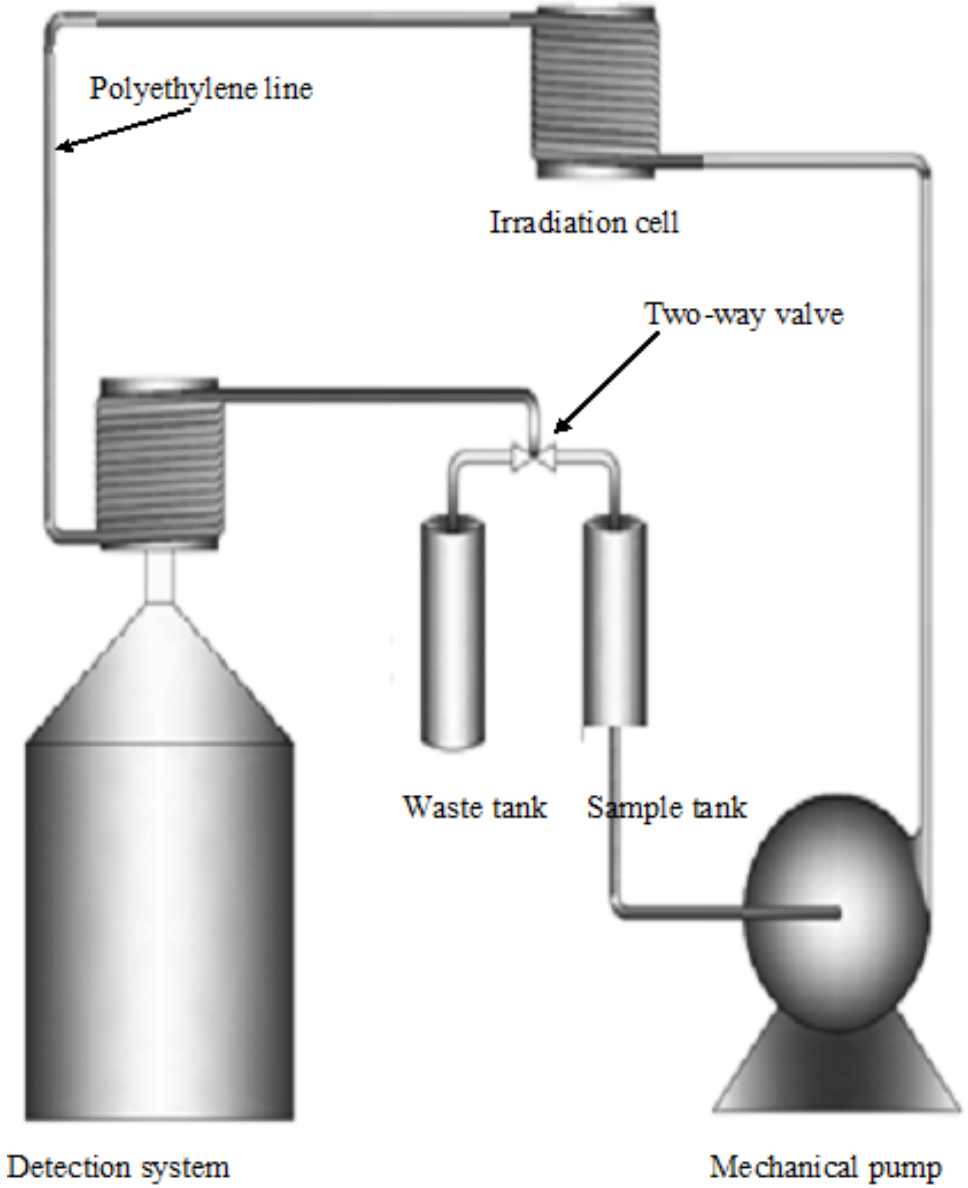
3.5- Trace Elements in Medical Plants Infusion……

It involves measurements of radioactive nuclides extracted from an irradiated herb which can be **interpreted in terms of isotopes, associated elements and concentrations** .

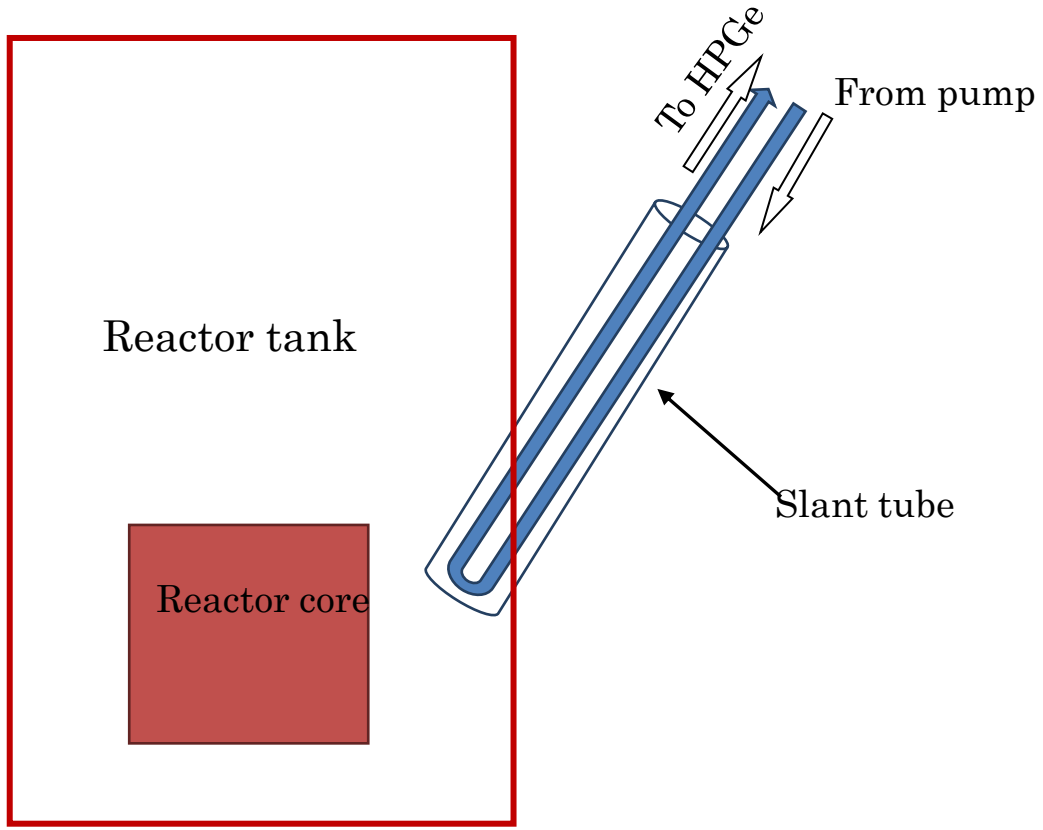


3.6 Flowing Sample NAA for analysis of liquids

- Simple and non-destructive
  - No pre-treatment and/or radio-chemical process
- Analysis of large volume
  - No pressure build-up
  - Measuring of short-lived isotopes
  - Easy to be installed with the currently available irradiation sites
- Analysis of solutions contained suspended matters
  - No need for filtration and/or dissolution steps
- Constant dead time
  - More accurate results
- No blank correction



Flowing Sample NAA set-up



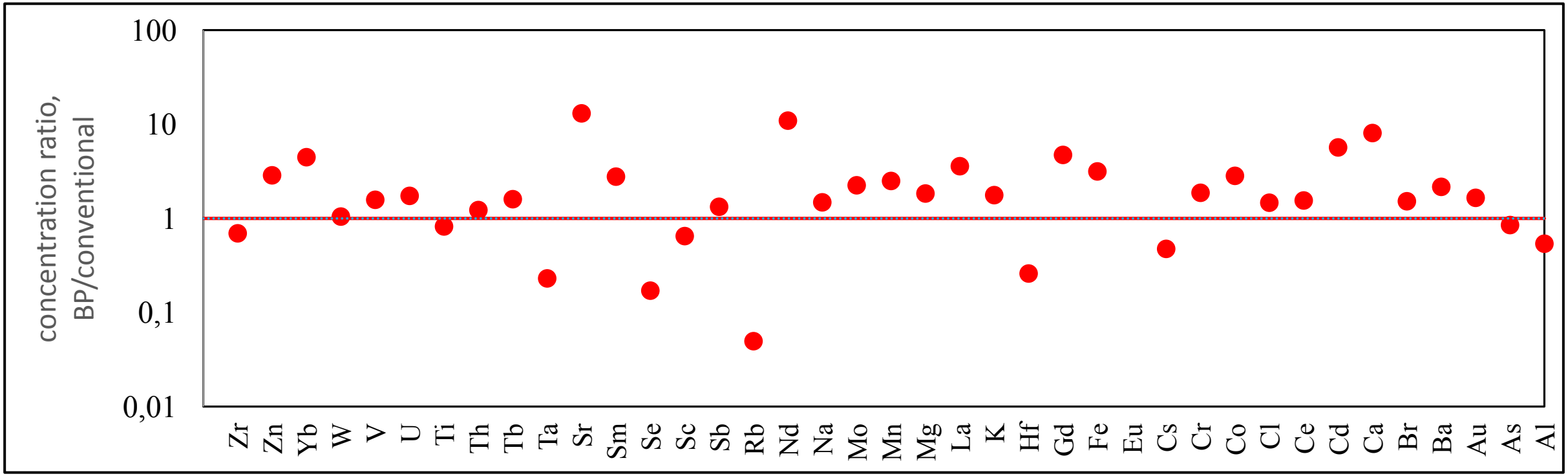
FSNAA setup installed in slant tube- Kyoto University

Analysis results of tap and river water samples

	Tap water		River water	
Element	ppb (µg/l ± %)	DL	ppb (µg/l ± %)	DL
O (^{19}O)	D		D	
Na	9700 ± 2	110	8800 ± 2	105
Mg	1300 ± 5	135	3720 ± 3	200
Al	25.5 ± 6	2.2	240 ± 1.3	2.0
S	8000 ± 25	7400	10500 ± 20	6600
Cl	D		D	
K	1350 ± 23	980	1350 ± 25	1180
Ca	10100 ± 4	280	15900 ± 2.5	240
V	0.40 ± 14	0.14	0.37 ± 15	0.15
Mn	1.7 ± 30	1.5	132 ± 2	1.9
Cu	28.0 ± 35	25	ND	
Br	D		D	
I	D		D	

D: detected only, DN: not detected

3.7 Plastic pollution: Are biodegradable (BD) plastics substitute or threat?



The ratios of the mass fraction of the measured elements in the BP and the conventional shopping plastics.

Attention!!!! BD plastic contains high levels of chemical elements and radioelements (K, Th, and U) – with high mobility

3.8 Soil-to-plant transfer of radionuclide and chemical elements.

IAEA CRP K41022 “Transfer of Radionuclides in Arid and Semi-Arid Environments for Radiological Environmental Impact Assessment”

Element
Mg
Mn
V
K
Al
Cl
Ca
U
Th
Br
La
Cr
Ba
Sr
Cs
Sc
Rb
Fe
Co
K-40
Ra-226

Those 19 stable elements are quantified using neutron activation analysis (NAA) in dry matter samples, with the elements in red are the primary aim of that work

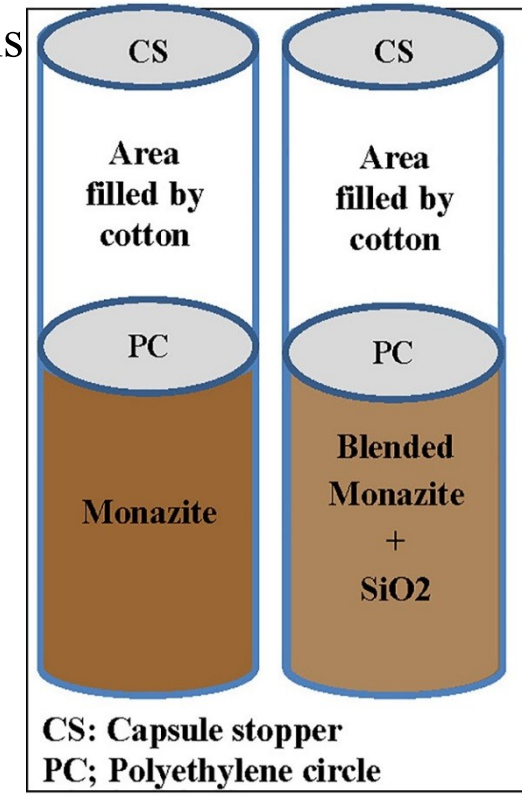
In addition to analysis of natural radionuclides of Ra-226 and K-40 in soil and plant parts ashed at 400 C using gamma-ray pectrometry - when the samples materials are enough for uantification.

3.9 Elemental analysis of monazite samples

Egypt has an abundance of monazite deposits known as “black sand” – ~60 % REEs, 6% Th, 0.2% U.

It is challenging to quantify REEs in monazite due to their high cross-section – neutron self-shielding issue.

We aim to estimate the neutron self-shielding correction factors through several dilutions with non-absorber material like SiO_2.



4- Future plans

- ✓ Installation of sub-Cd irradiation facility
- ✓ Installation of FSNAA in ETRR-2
- ✓ Automation of NAA – sample changer

5- Collaboration opportunities (ETRR-2)

Area of interest

- ✓ Archeology,
- ✓ Environmental studies
- ✓ Automation
- ✓ PGNAA
- ✓ Neutron beam experiments
- ✓ RI production
- ✓ Si doping

We can offer

- ✓ Free access to our irradiation facilities & joint research projects

We are looking for technical/financial support in

- ✓ Automation of NAA
- ✓ Beam tube experiments.
- ✓ Si doping
- ✓ RI production

Thanks for your kind attentions

شكراً علي حسن استماعكم