



Neutron Activation Analysis applications at the IBR-2 reactor

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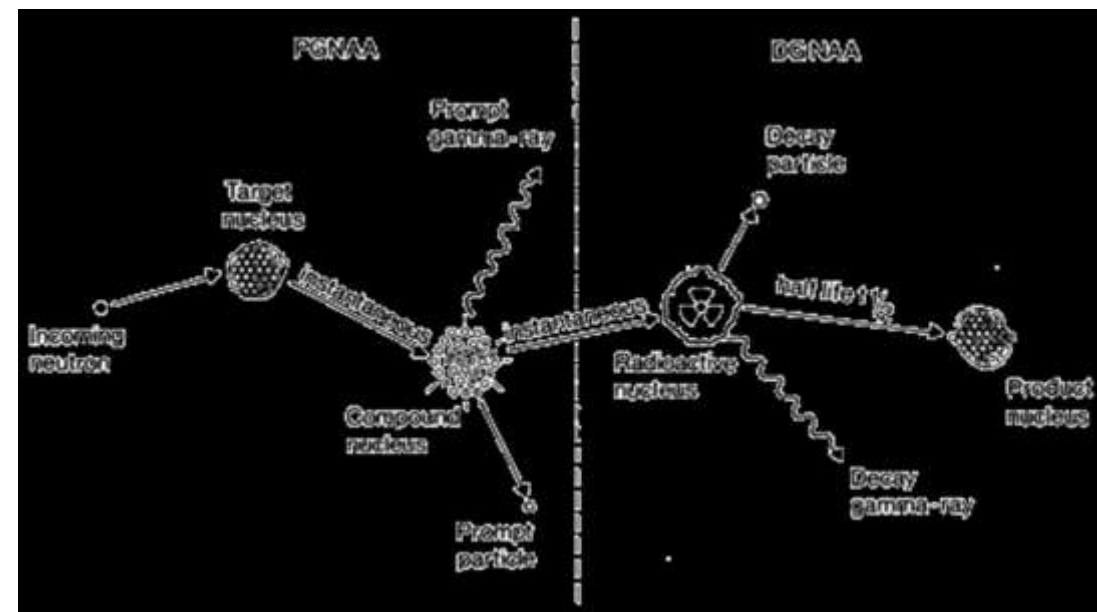
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Neutron activation analysis is an isotope specific analytical technique for the qualitative and quantitative determination of elemental content

The method is based upon the conversion of stable atomic nuclei into radioactive nuclei by irradiation with neutrons and the subsequent detection of the gamma radiation emitted during the decay of these radioactive nuclei. Activation by neutrons may result in radionuclides from all elements (that have radioactive daughter products) present in the sample, with sometimes strongly different production rates

P. Bode, J. J. M. de Goeij,
'Activation Analysis',
Encyclopedia of Environmental
Analysis and Remediation,
J. Wiley & Sons, New York, **1998**,
ISBN 0-471-11708-0, pp 68–84





Hilde LEVI
1909-2003

Neutron activation was discovered in **1936** when Levi and Hevesy found that samples containing certain rare earth elements became highly radioactive after exposure to a source of neutrons.

From this observation, they quickly recognized the potential of employing nuclear reactions on samples followed by measurement of the induced radioactivity to facilitate both qualitative and quantitative identification of the elements present in the samples.



Georg Karl von HEVESY
1885-1966

Advantages

- (1) ease of sample preparation (applied instrumentally - no need for sample digestion or dissolution);
- (2) high precision;
- (3) simultaneous measurement of multiple elements;
- (4) outstanding replicability;
- (5) excellent inter-laboratory comparability.
- (6) detects the total elemental content, regardless of oxidation state, chemical form or physical location



ISINN-26, Xi'an, China

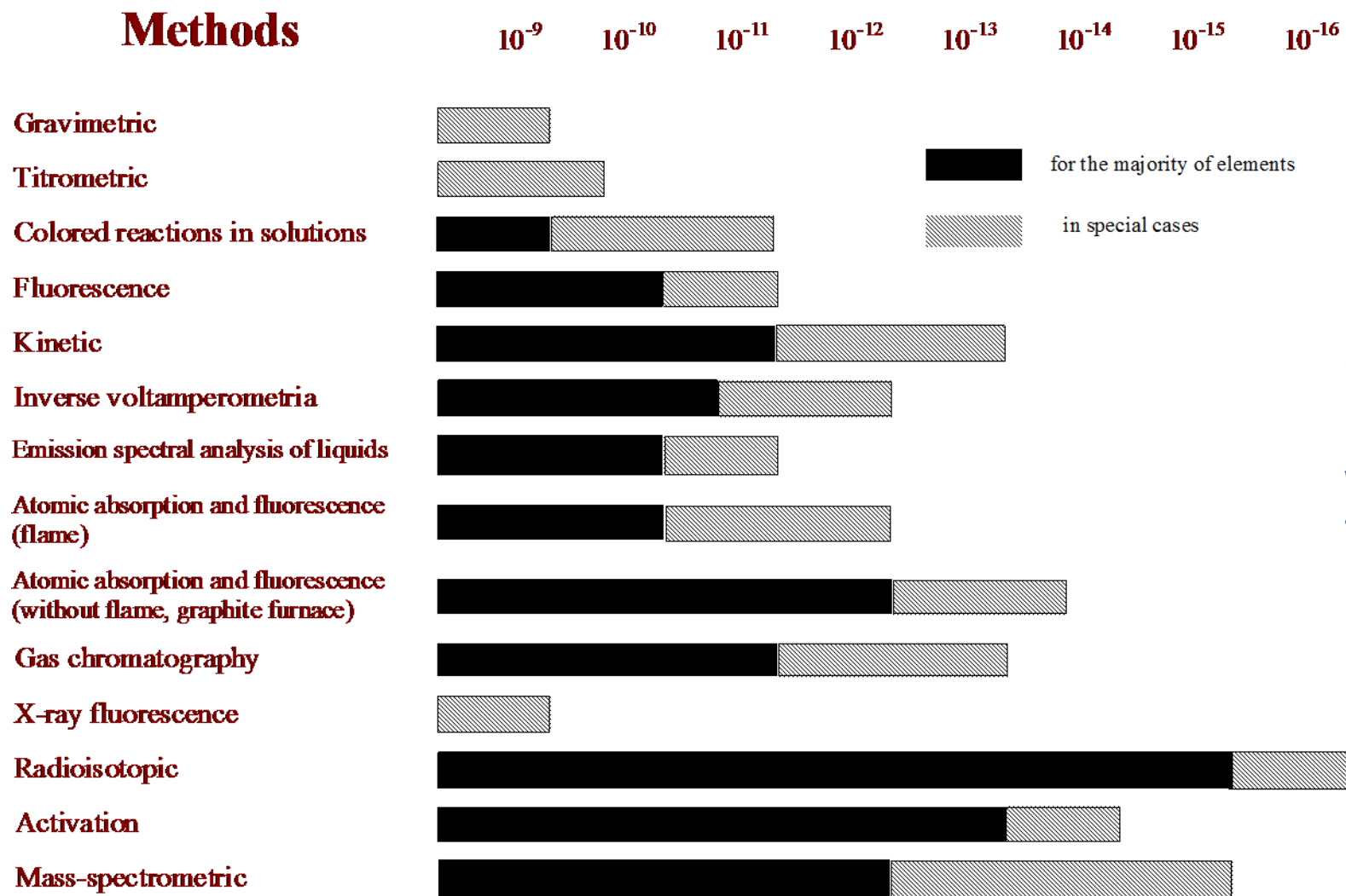


Limitations

- (1) need of neutron source (reactor preferably)
- (2) not all elements (including environmentally relevant) are detectable
- (3) detects the total elemental content, regardless of oxidation state, chemical form or physical location.



Absolute detection limit, g



NAA is generally recognized as the "referee method" of choice when new procedures are being developed or when other methods yield results that do not agree.

Metrology in Chemistry

CHIMIA 2009, 63, No. 101

**Neutron Activation Analysis:
A Primary (Ratio) Method to Determine SI-Traceable
Values of Element Content in Complex Samples**

Bureau
International des
Poids et
Mesures

2007

**Consultative Committee
for Amount of Substance:
Metrology in Chemistry
and Biology**



Peter BODE
Delft University
of Technology
The Netherlands



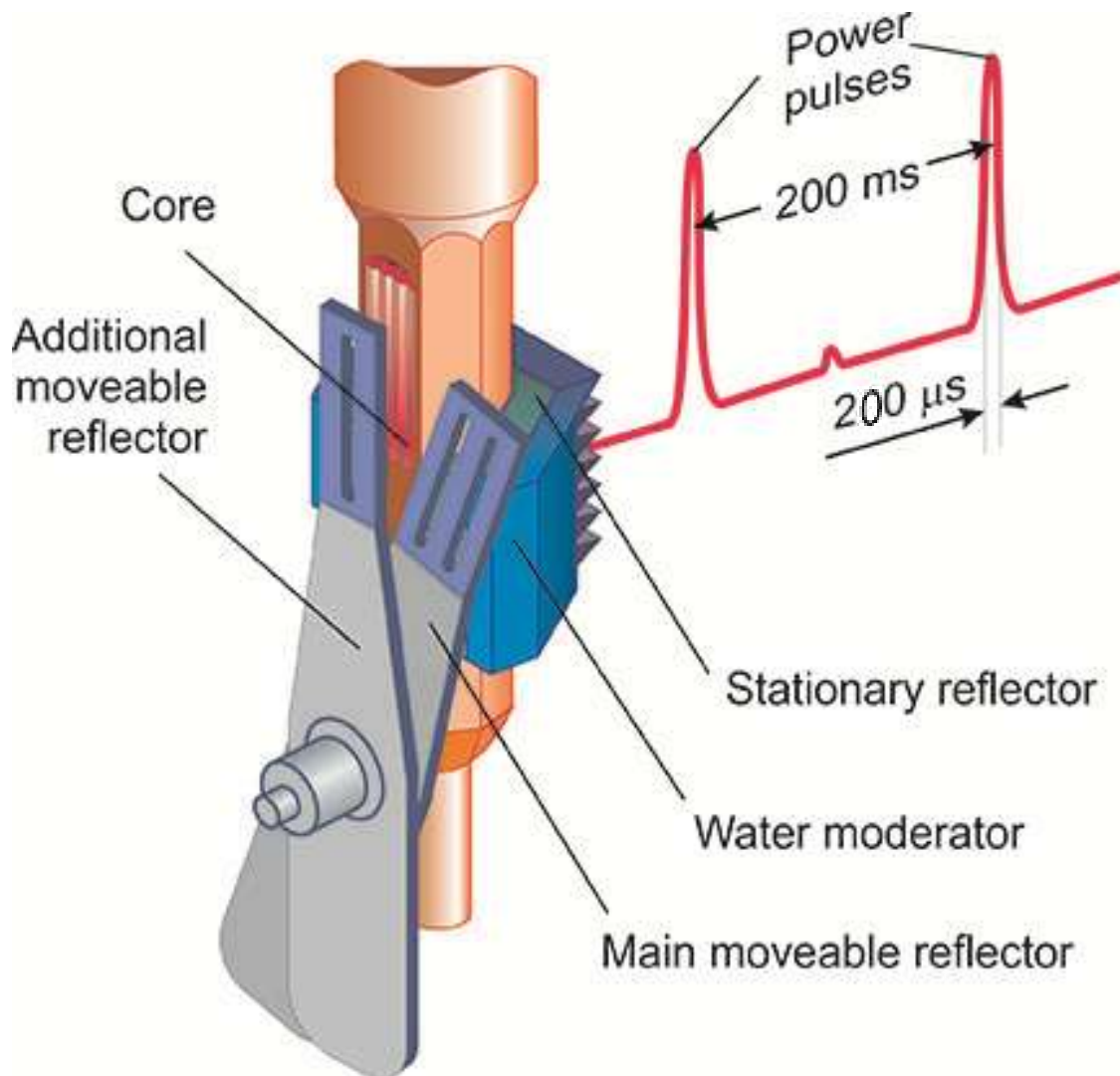
Robert GREENBERG
National Institute of Standards
and Technology, NIST
USA



Elisabete FERNANDES
Univer. de Sao Paulo Centro de
Energia Nuclear na Agricultura
Brazil

Accepted that “neutron
activation analysis
should have the similar
status as the methods
originally listed by the
CCQM as 'primary
methods of
measurement’ “

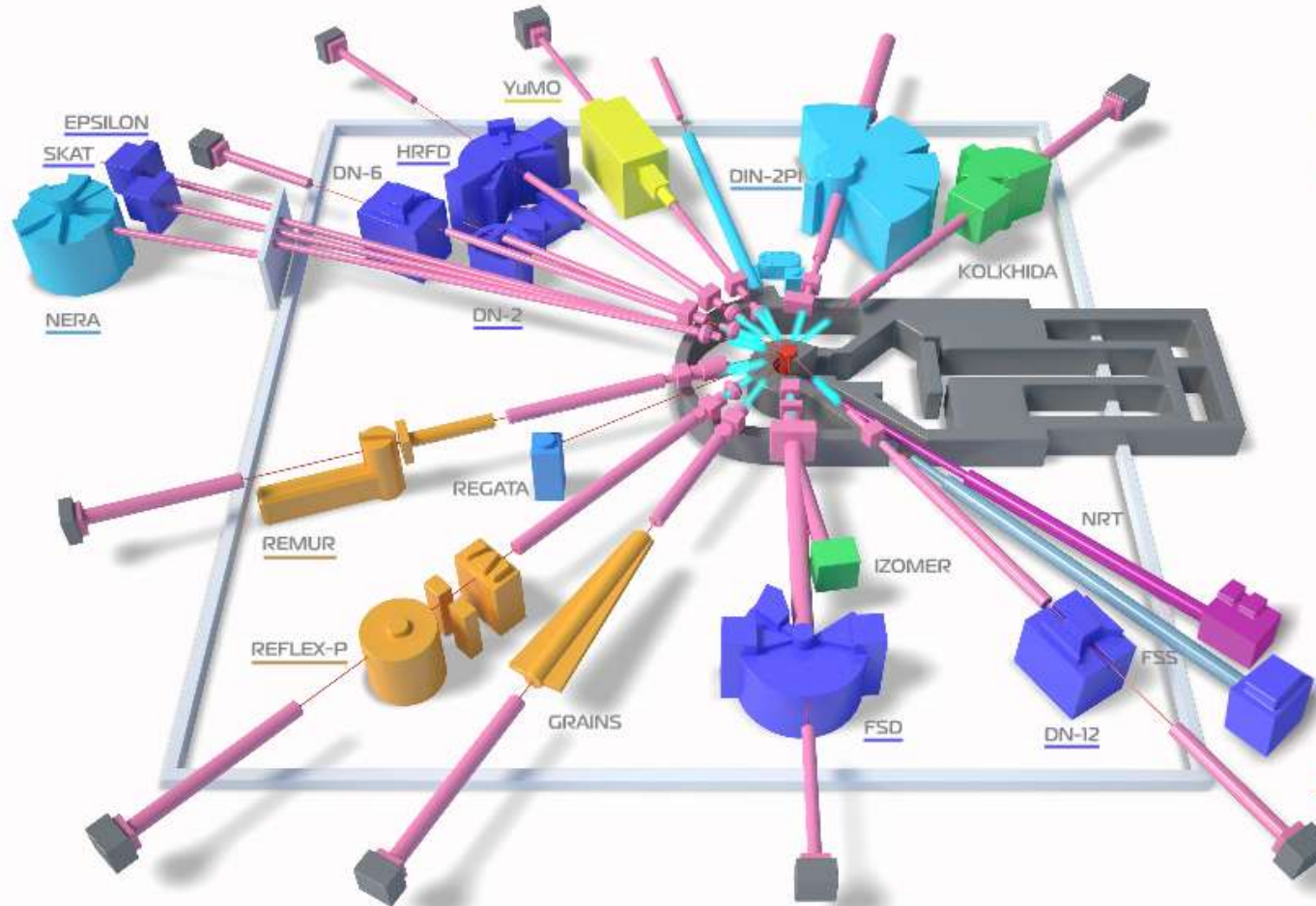
IBR-2 @ FLNP JINR



Average power, MW	2
Fuel	PuO ₂
Number of fuel assemblies	69
Maximum burnup, %	9
Pulse repetition rate, Hz	5; 10
Pulse half-width, μ s:	
fast neutrons	200
thermal neutrons	340
Rotation rate, rev/min:	
main reflector	600
auxiliary reflector	300
MMR and AMR material	nickel + steel
MR service life, hours	55000
Background, %	7.5
Thermal neutron flux density from the surface of the moderator:	
- time average	$\sim 10^{13}$ n/cm ² ·s
- burst maximum	$\sim 10^{16}$ n/cm ² ·s

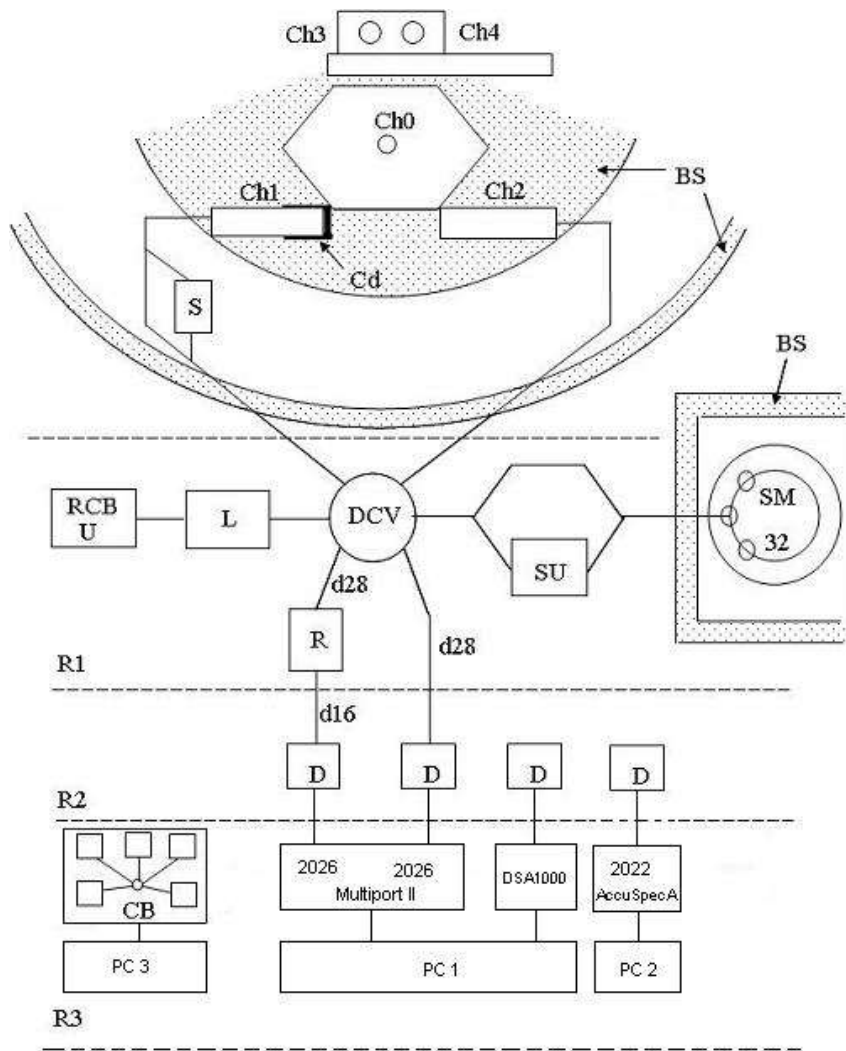
IBR-2 experimental facilities

14 beam ports
 19 facilities



- Diffraction**
 DN-2, DN-12, DN-6, FSD, FSS, HRFD, SKAT, EPSILON
- Small-angle scattering**
 YuMO
- Reflectometry**
 GRAINS, REFLEX-P, REMUR
- Inelastic scattering**
 DIN-2PI, NERA
- Nuclear Physics**
 IZOMER, KOLKHIDA
- Neutron Activation Analysis**
 REGATA
- Neutron imaging**
 NRT

Experimental facility REGATA at IBR-2 reactor

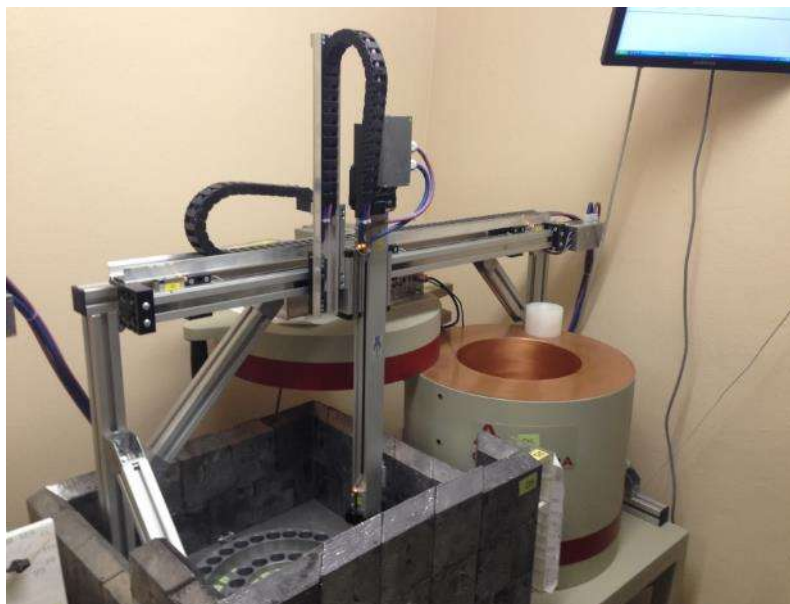
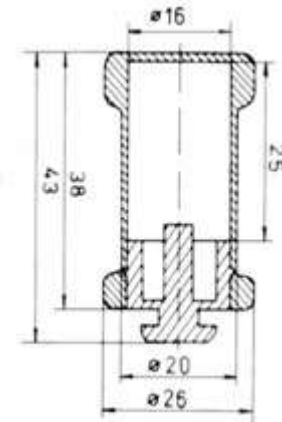


Ch1&Ch4 –irradiation channels, S- intermediate storage, DCV- directional control valves, L- loading unit, RCB- radiochemical glove-cell, U- unloading unit, SU- separate unit, SM- storage magazine, R- repacking unit, D- detector, CB- control board, R1-R3- the rooms where the system is located.

Pneumatic transport system

4 detectors

automatic sample changer



Transport capsules for irradiation



Detectors

№	Detector name	Type	Model	Producer	Rel. efficiency, Resolution	Delivery date	High voltage Power Supply	Amplifier	ADC	Software	Spectrum size
1	Д1	HPGe	GC4020-7500SL	Canberra	42%, 1.76 keV	2014 г.	3106D Canberra	2026 Canberra	Multiport II	Genie-2000	8к
2	Д5	HPGe	GC4018-7500SL	Canberra	45.7%, 1.75 keV	2015 г.	3106D Canberra	2026 Canberra	Multiport II	Genie-2000	8к
3	Д6	HPGe	GX4020-CRIO-JT	Canberra	41.8%, 1.81 keV	2009 г.	Digital Spectrum Analyzer DSA-1000			Genie-2000	8к
4	Д7	HPGe	GC5519/7500SL	Canberra	56.4%, 1.85 keV	2016 г.	Digital Signal Analyzer DSA-LX			Genie-2000	8к

- Data processing and determination of element concentrations is performed using commercial software Genie 200 and in-house software developed in FLNP JINR

Relative method based on CRM is used

Solid samples are irradiated, only

S. Pavlov, S. Dmitriev, A.Yu. I.A.Chepurchenko, M.V. Frontasyeva, Automation system for measurement of gamma-ray spectra of induced activity for neutron activation analysis at the reactor IBR-2 of Frank Laboratory of Neutron Physics at the Joint Institute for Nuclear Research.
Phys. Particles Nuclei 11 (6), 737–742 (2014)

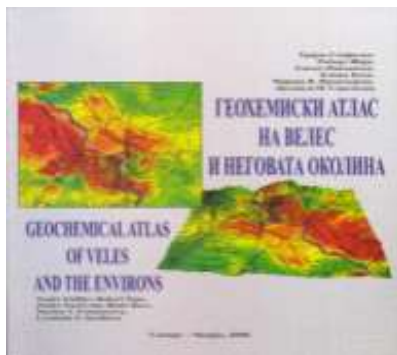
A Primary (Ratio) Method to Determine SI-Traceable Values of Element Content in Complex Samples

H							NAA										He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac**											Rf	Db	Sg	Bh	Hs
	*	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
	**	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lw		

Neutron Activation Analysis

...investigating the environment

Determination of a large number of potential pollutants in air and monitoring of their time and spatial distribution.



International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops.

... cleaning our environment

Development of biological methods for *waste water treatment* is very important to reduce the secondary pollution with chemicals.

... studying the food stuffs

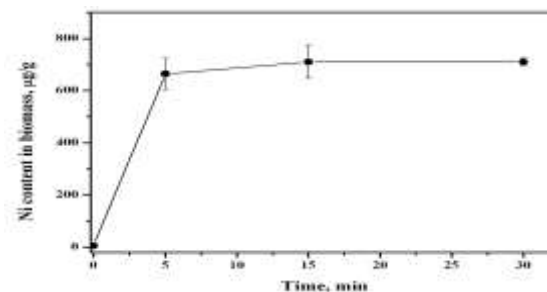
Determination of the elemental content in herbs and other food stuffs *in order to assess the excess or the lack of some elements in samples.*



The elemental content of major food stuffs is a major factor in human metabolism. The lack or excess of some microelements can induce some diseases.



The elemental content of herbs used in medicine and cosmetics can influence their benefit for health. The content of forages can influence the milk productivity and cattle health.



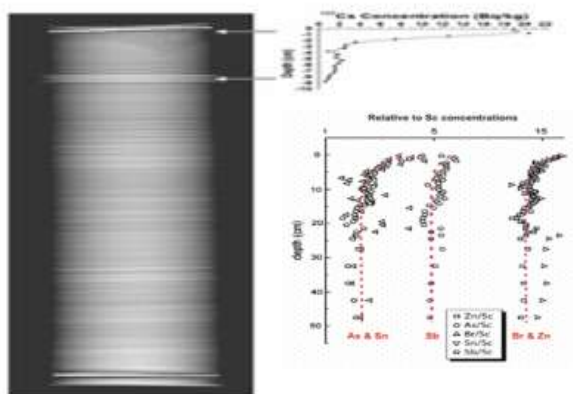
Study of nickel uptake by cyanobacteria *Nostoc linckia* from chemically complex wastewater effluent.

ISINN-26, Xi'an, China

Neutron Activation Analysis

... understanding the Earth

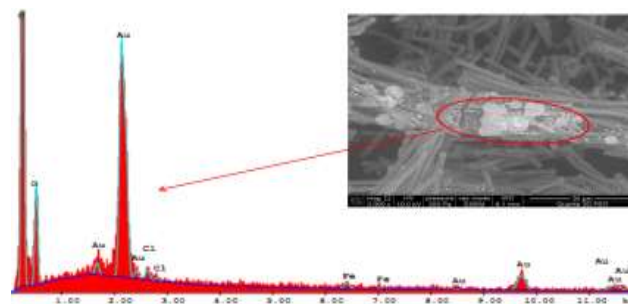
The element content of geological samples can provide *information on the Earth formation and evolution*



Geochronology and retrospective pollution study of the deep sea sediments.

... creating our future

Study the biosynthesis of nanoparticles by various microorganisms or improving the production process of some industrially important materials.



ISINN-26, Xi'an, China

... studying the heritage

Determination of the elemental composition of the artifacts can provide information on the development and interaction of different cultures, authenticity of the artifacts or can help in choosing best materials for restoration.



Obsidian is certainly the lithic material providing archaeologists with the clearest evidence of contact between different cultures.

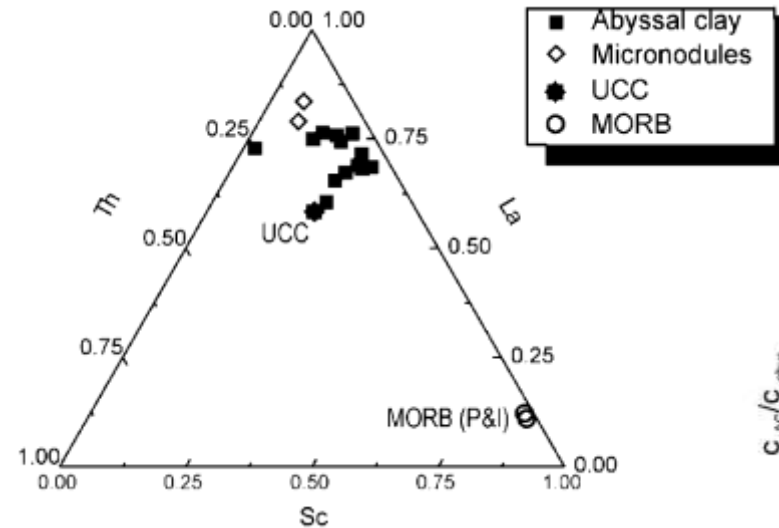
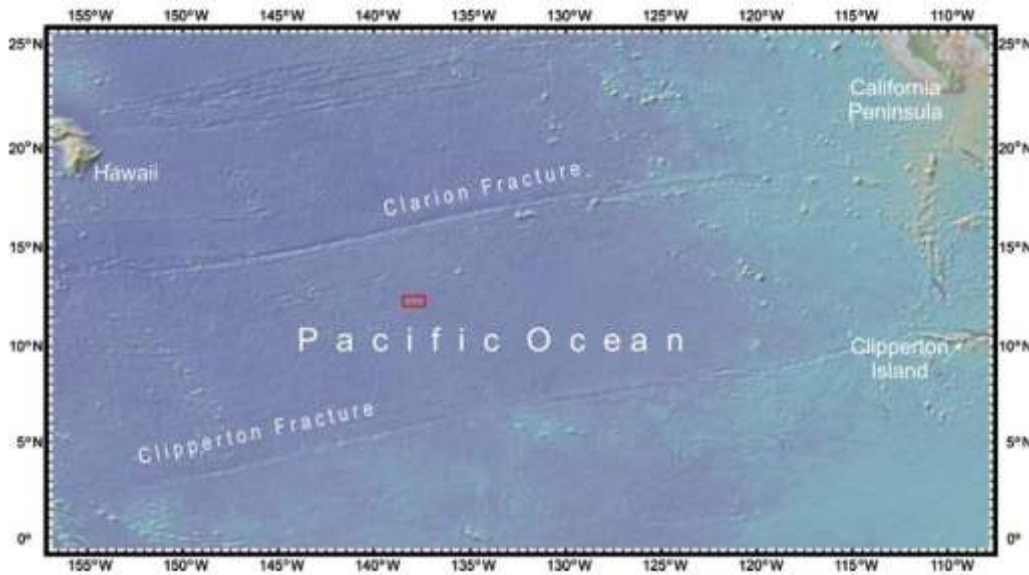
The resulting biomass containing nanoparticles of 10-80 nm can be used for both industrial and medical purposes.

... UNDERSTANDING THE EARTH: Micronodules & abyssal clay

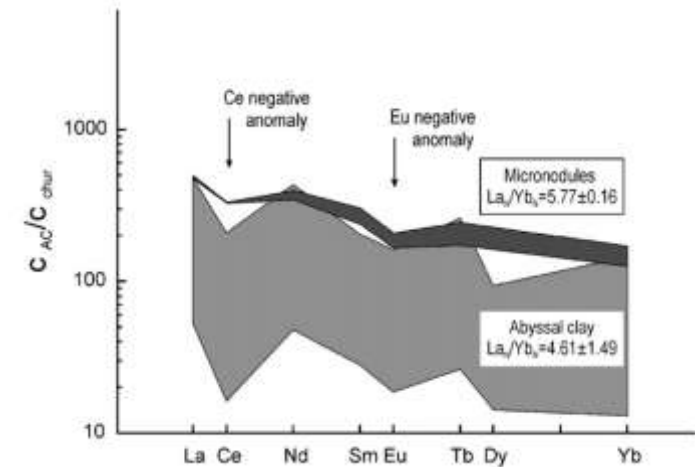
- Pacific Ocean Polymetallic nodules and abyssal clay consists of sedimentary material carried by water
- This peculiarity allowed to investigate their geochemistry within the Upper Continental Crust (UCC) model, allowing to evidence some **minute differences with respect to UCC**, useful in reconstructing their origin

University of Bucharest, IFIN-HH, NI for R&D of Marine Geology and Geoecology (GeoEcoMar), Romania

- Chondrite normalized REE plot shows a significant negative anomaly:
Ce - characteristic to hydrogenous nodules;
Eu – specific to the UCC material



Ternary discrimination shows the significant differences with respect to fresh oceanic basalt (MORB)



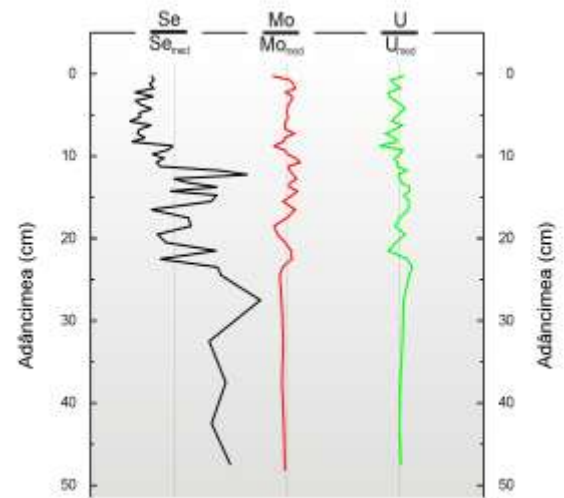
- Micro-polymetallic nodule (two sets) and abyssal (13 samples) clay collected at a depth of 4500m by the R/V Akademik Alexandr Karpinski in the Clarion-Clipperton Province of the North Pacific Ocean

O.G. Dului, C.I. Cristache, O.A. Culicov, M.V. Frontasyeva, S.A. Szobotca, M. Toma
Epithermal neutron activation analysis investigation of Clarion-Clipperton abyssal plane clay and polymetallic micronodules
Applied Radiation and Isotopes, 2009, 67(5):939-43

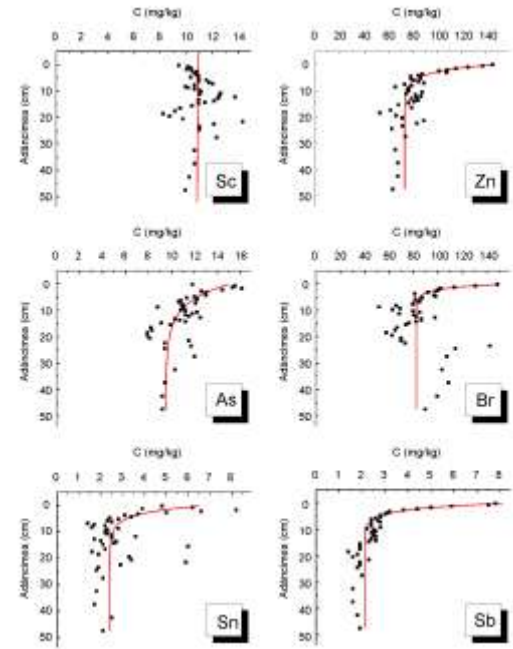
... UNDERSTANDING THE EARTH: Black Sea euxinic sediments



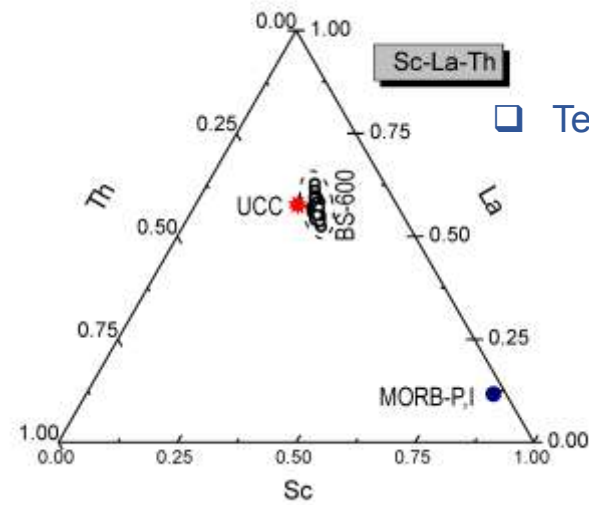
- 0.5 m column of sediments collected at a depth of 600 m on the slope of the Western Black Sea continental platform.
- ²¹⁰Pb and ¹³⁷Cs vertical profiles, allowed to estimate the age of the entire core to 1000 ± 50 y.



- Vertical profiles of redox sensitive Se, Mo and U proving the steadiness of the euxinic conditions during the last 1000 years

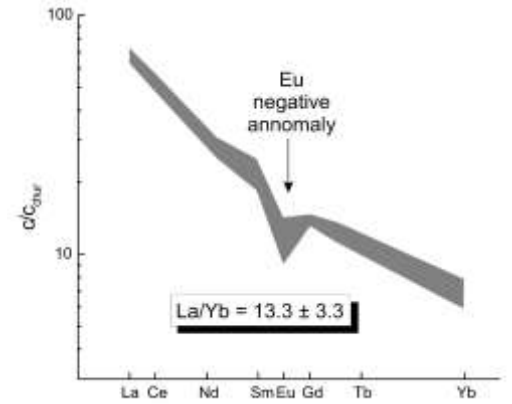


ISINN-26, Xi'an, China



University of Bucharest, Romania
IFIN-HH, Romania

- Ternary discriminating diagrams confirm the continental origin as well as the relative homogeneity of sediments



- Vertical profiles of presumed anthropogenic elements suggest the development of the industrial activity in the last two centuries
- The REE content normalized to chondrite shows a weak Ce positive anomaly (reducing environment) and strong Eu negative anomaly (continental origin)

O.G. Dului, C.I. Cristache, G. Oaie, O.A. Culicov, M.V. Frontasyeva, M. Toma
ENAA Studies of pollution in anoxic Black Sea sediments
Marine Pollution Bulletin, 2009, 58(6):827-831

...STUDYING THE HERITAGE: icons

Lat. *hereditare* - condition or state transmitted from ancestors

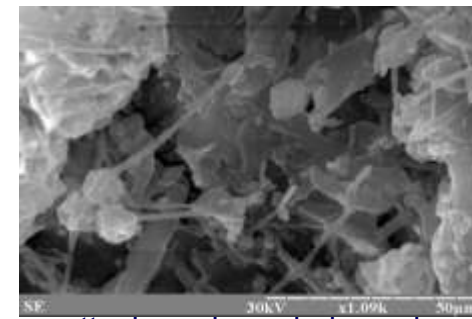


- The pigments used were of local origin, most of them of mineral source such as lead white, cinnabar, orpiment, minium or ocher, but in few cases exotic mineral pigments such malachite, azurite or lapis-lazuli were used too.
- Viridian: $Cr_2O_3 \cdot nH_2O$ (1856), Cadmium yellow: CdS (1840) Zinc white: ZnO (1850), Titanium white: TiO_2 (1921) Prussian blue: $Fe_4[Fe(CN)_6]_3 \cdot x H_2O$ (1708)



DR gives the first information on pigments, state of conservation on previous restorations or repaintings.

University of Bucharest, Romania
IFIN-HH, Romania



Fungus attack on degraded wooden plate.



XRF
FT IR
NAA

- A complex of analytical techniques was used to investigate nine orthodox icons from Russia, Northern Dobrogea, Transylvania and Walachia, painted between the end of XVIIIth and second half of the XIXth century.

- Digital radiography, X-rays Fluorescence, Fourier-transform IR and Raman spectroscopy as well as ENAA evidenced a multitude of details such as mechanical defects, former interventions and restorations, as well as the nature of pigments and binders.

- If the visual inspection shows significant degradations of the wooden plate, **SEM** can elucidate the cause

- It was proved, that, despite stylistic diversity and locations, all icons were painted by using relatively similar materials, which in fact reflects significant cultural and religious contacts.

IO.G.Duliu, Sister Serafima, B. Constantinescu, M.-M. Manea, O. A. Culicov, I. Zinicovscaia, M.V. Frontasyeva
ENAA, XRF, Digital Radiography, FT-IR and Raman Spectroscopy Investigation of Nine Russian and Romanian Icons from XVIII –XIXth Century
In print

Holy Trinity (Transylvania) XIXth century (second half)

- Vermeil
- Ochre
- Ochre + lead white
- Azurite + lead white + Au + Ag
- Lead white
- Ochre + chrome yellow + lead white



...STUDYING FOODSTUFFS: medical herbs

□ Sample collection:
Hangai, Douria, Kobodo, Mongolia-Altai Mountains.

□ These regions are characterized by of anthropogenic impact because high level of urbanization and industrialization and assessment of quality of plant used for medical purposes is very important.



Carduus crispus L. *Sanguisorba officinalis* *Granium pratense* *Chamaenerion Angustifolium* (L) Scop



□ World Health Organization estimates that 70% of the world population use herbal medicines and herbal products for primary health care

School of Chemistry and Chemical Engineering, NUM, Mongolia Medical college "Monos", Mongolia

□ A total of **35** elements were determined in the plant species and associated soil sam

□ Mg, K, Ca, Mo, Br, and U 10 – 129 for Br suggests that the concentration levels of these elements in plants is affected by characteristics of plants as well as the local environment.

□ Concentrations of toxic heavy metals in the studied plants are below the Maximum Permissible Levels.

□ The results obtained can be used for control and monitoring in production of pharmaceutical on the base of medical plants.

Baljinnyam N., Tsevegsuren N., Jugder B., Frontasyeva M.V., Pavlov S.S., 2014. Investigation of Elemental Content of Some Medicinal Plants from Mongolia. International Journal of Medicinal Plants. Photon 106, 481-492.

...STUDYING FOODSTUFFS: wine

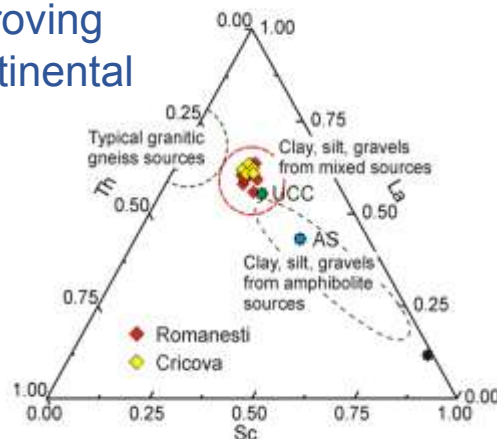


Cabernet, Regent, Pinot Noir, Merlot, Malbec, Sauvignon, Riesling, Pinot Gris, Muscat, UniBlanc

Pinot, Chardonnay, Cabernet, Pinot Noir

35 elements in soil
18 elements in wine

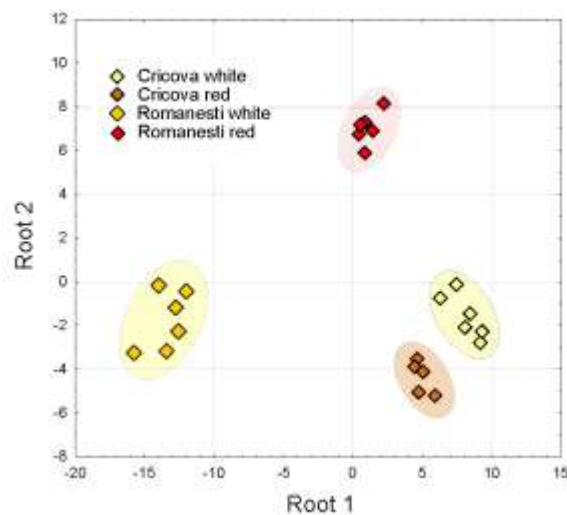
The Sc-La-Th discriminating ternary diagram proving a primary continental origin and homogeneity of the soil material



Institute of Chemistry of the AS of Moldova, Technical University of Moldova

- Na, Mg, Al, K, Ca, Mn, and Fe, and only 10 soluble trace elements, i.e., Co, Ni, Zn, As, Br, Rb, Sr, Sb, Cs, Ba, and U, whose concentrations were above the detection limits
- Organisation International de la Vigne et du Vin: International Code of Oenological Practices
Na, Zn, As, Br

The discriminating Root2 vs. Root 1 bi-plot illustrating the result of Discriminate Analysis. It can be remarked that the Romanesti wines are better discriminated with respect to Cricova ones.



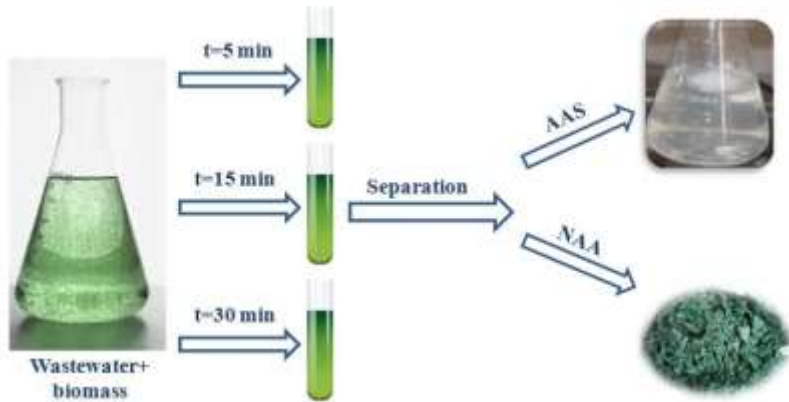
Transfer factor

$$TF_i = \frac{C_{i,wine}}{C_{i,soil}}$$

- All types of wine presented a high content of K
- K, Br and Rb present the highest TF
- Br is an essential element for vineyard development, in the case of Rb one possible explanation could be related to the ionic radius of Rb equal to 1.52 pm, closer than any other alkaline elements to the K ionic radius of 1.37 pm

I. Zinicovscaia, O. G. Dului, O. A. Culicov, R. Sturza, C. Bilici, S. Gundorina
Geographical Origin Identification of Moldavian Wines by Neutron Activation Analysis
Food Anal. Methods (2017) 10:3523–3530

...CLEANING OUR ENVIRONMENT : wastewaters



Experimental scheme

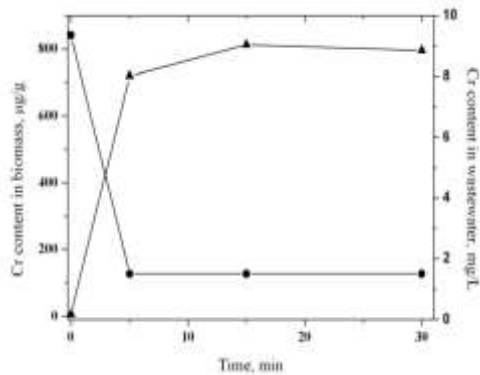
□ During 30 min of experiment 84% of chromium and 50% of nickel were removed from the wastewaters.

□ During 30 min of experiment the content of iron, nickel and zinc in biomass increased by 84%, 98%, and 88%, respectively.

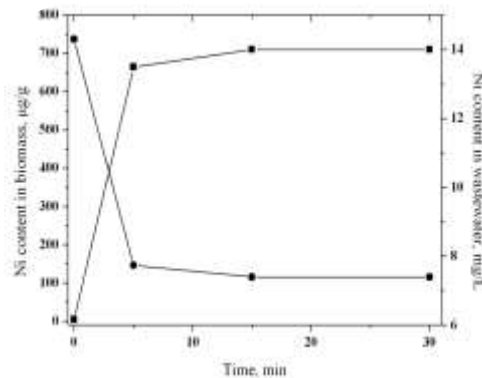
Institute of Microbiology and Biotechnology of the AS of Moldova

Nickel content in the *Nostoc linckia* biomass and in the wastewater versus the contact time

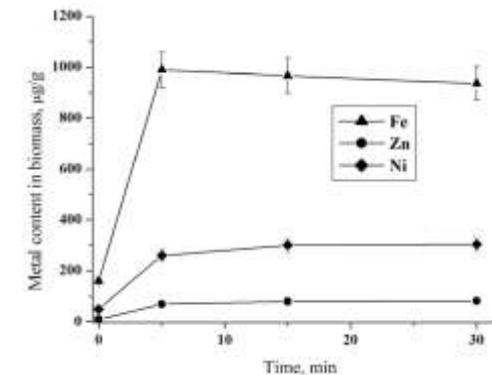
Fe, Ni, and Zn concentrations in *Nostoc linckia* biomass as a function of the contact time with the wastewater containing chromium



Chromium content in the *Nostoc linckia* biomass and in the wastewater versus the contact time



ISINN-26, Xi'an, China



I. Zinicovscaia, L. Cepoi, A. Valuta, L. Rudi, O. A. Culicov, M. V. Frontasyeva, E. I. Kirkesali, S. S. Pavlov and T. Mitina
Nostoc Linckia as Biosorbent of Chromium and Nickel from Electroplating Industry Wastewaters
Journal of Materials Science and Engineering B 4 (8) (2014) 242-247



EUROPEAN EXHIBITION OF CREATIVITY AND INNOVATION



...CLEANING OUR ENVIRONMENT : wastewaters

University of Oulu, Finland

- The removal of anions (nitrate, sulphate, phosphate) and metals from mining effluents and industrial wastewaters is important for reducing risks to the environment and human health
- ion exchange resins mainly based on oil-based chemicals
- lignocellulosic materials—e.g. sawdust and straw—as a bio-based platform
 - quaternized pine sawdust (QPSD)

Content in mg/kg, * g/kg, ** μg/kg

Sample	Na	Mg*	Al	S*	Cl*	Ca
1	5.2 ± 0.5	-	-	8.18 ± 1.6	69.4 ± 6.7	-
2	118 ± 11	1.32 ± 0.13	38 ± 4	10.5 ± 2.1	1.21 ± 0.12	309 ± 46
3	39 ± 4	-	33 ± 4	7.81 ± 1.56	71.5 ± 7.15	-

Sample	Sc**	V	Cr	Mn	Fe	Co
1	5 ± 1	0.1 ± 0.01	1.5 ± 0.4	6.4 ± 0.6	36 ± 5	0.04 ± 0.004
2	20 ± 4	1.8 ± 0.3	3.1 ± 0.9	31 ± 3	152 ± 23	7.4 ± 0.7
3	40 ± 8	3.1 ± 0.5	4.7 ± 1.4	4.9 ± 0.5	40 ± 6	48 ± 5

Sample	Ni	Zn	As	Br	Mo	Sb
1	0.6 ± 0.1	1.9 ± 0.2	0.03 ± 0.003	0.9 ± 0.04	0.06 ± 0.01	0.01 ± 0.001
2	42 ± 8	12 ± 1	1.01 ± 0.1	2.8 ± 0.1	4.6 ± 1.4	0.4 ± 0.04
3	95 ± 19	7.6 ± 0.8	0.2 ± 0.02	10 ± 2	1.2 ± 0.3	0.3 ± 0.03

Sample	I	Cs**	La**	W	U
1	-	4 ± 0.8	20 ± 3	0.03 ± 0.009	0.006 ± 0.0006
2	0.2 ± 0.06	20 ± 4	20 ± 3	0.1 ± 0.03	1.5 ± 0.1
3	-	30 ± 6	40 ± 6	0.1 ± 0.03	3.5 ± 0.3

- Column mode - to imitate a real industrial on exchange process

- 23 elements: NAA before/after use in non-regenerated /regenerated mode with NaCl
- 28 elements: ICP-OES&ICP-MS in mining wastewater before/after treatment with QPSD

- Contrary to the hypothesis, nitrate removal from mining wastewater with QPSD was very moderate.
- But, a nickel reduction of over 84% was observed both in column and batch mode.
- Nickel removal - efficient even at 5°C but the sorption rate was lower than at 23°C.

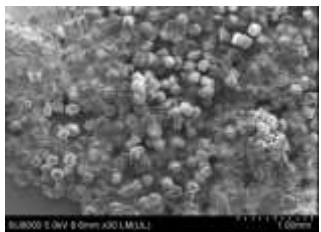
- The nickel-selectivity of the material would make it a good candidate for the treatment of dilute nickel-containing wastewaters.
- Chemically modified pine sawdust could be used for the treatment of real mining wastewaters, preferably having a lower level of conductivity.
- The efficacy of the sorption process is strongly dependent on the composition of the wastewater being treated.
- This study showed how vital it is to investigate sorption phenomena using real wastewaters, since the sorption behavior with synthetic solutions does not necessarily correlate well with real wastewaters
- The NAA results provide valuable information about the sorption and desorption of various components on and off the QPSD.

ISINN-26, Xi'an, China

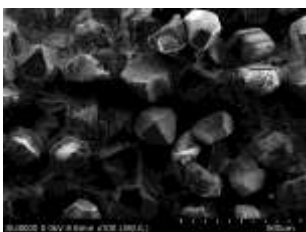
A. Keränen, T. Leiviskä, I. Zinicovskaia, M. V. Frontasyeva, O. Hormi
J. Tanskanen
Quaternized Pine Sawdust in the Treatment of Mining Wastewater
Environmental technology (2016) volume 37, issue 11, 1390-1397

...CREATING OUR FUTURE: artificial diamonds

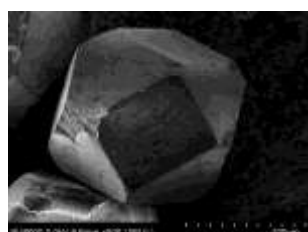
Diamond powder AC 100 160/125 up to 500/400 μm Fe-Ni-C system



zoom x 30



zoom x 100

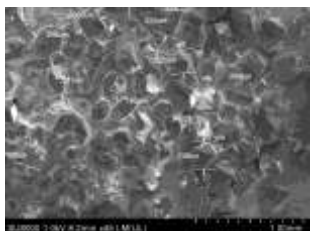


zoom x 500

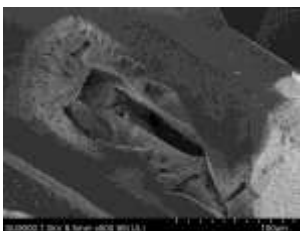


zoom x 500

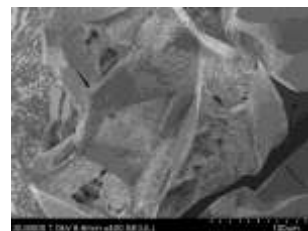
Diamond powder AC 15 250/200 μm Mn-Ni-C



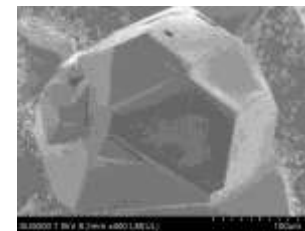
zoom x 45



zoom x 500



zoom x 400



zoom x 400

scanning electron microscopy (SEM)

- ❑ Diamonds formed in Mn-Ni-C system in comparison with Fe-Ni-C system have larger concentrations of Mn, Al, Cr, La, Sm, W, Au, and Th.
- ❑ Fe-Ni-C system makes it possible to synthesize diamond powders with less technological impurities.
- ❑ Fe-Ni-C system is potentially promising as a base for the development of the technologies for high-strength diamond powder production, while the Mn-Ni-C system has great potential as a base for developing technologies for obtaining medium strength diamond powders

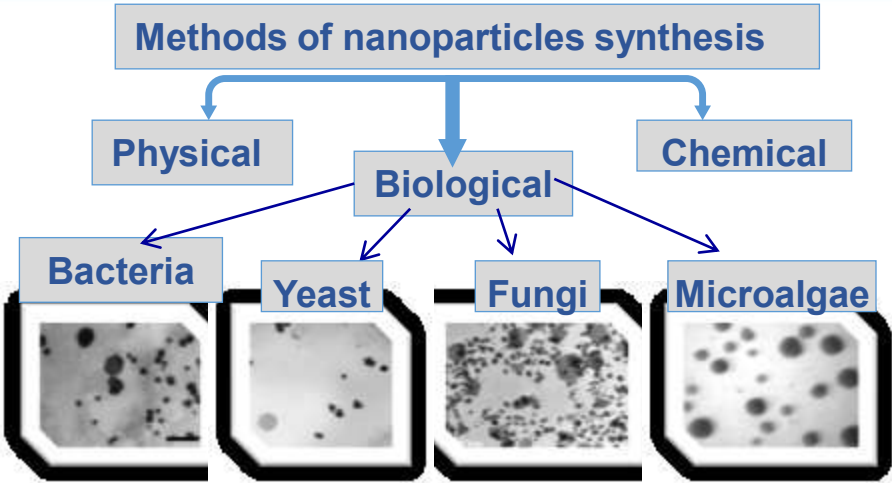
ISINN-26, Xi'an, China

SSPA "Scientific and Practical Materials Research Centre of NAS of Belarus"

- ❑ manufacture of abrasive tools
medical applications: drug delivery devices, microelectromechanical devices, and cardiovascular devices
- ❑ carbon, carbonyl iron, catalysts such as Mn-Ni and Fe-Ni
5 GPa and temperature of 1670–1910 K
in a hard-metal chamber of «anvil with a hole» type
- ❑ In Fe-Ni-C system speed of diamond formation is slower than in Mn-Ni-C system what allows to crystal grow with regular shape and to distribute load proportionally
- ❑ ENAA allowed determination of 38 elements (Na, Mg, Al, Cl, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Zn, As, Se, Br, Sr, Zr, Nb, Mo, Ag, In, Sb, I, Ba, Cs, La, Nd, Sm, Eu, Gd, Tb, Hf, Ta, W, Au, Th, and U) with a wide concentration range from 0.006 mg/kg to 9 g/kg.
- ❑ I, Ba, Ta, and Mo are impurities. Cl came from acid used for purification of the samples. Some other elements diffuse from material of container.

Yu. V. Aleksiyenak, O. V. Ignatenko, S. V. Leonchik, V. A. Komar, A. V. Konovalova, M. V. Frontasyeva
Neutron activation analysis and electron microscopy investigations of crystallization processes and characteristics of diamonds in the C-Mn-Ni-Fe systems
J Radioanal Nucl Chem (2016) 309:267–271

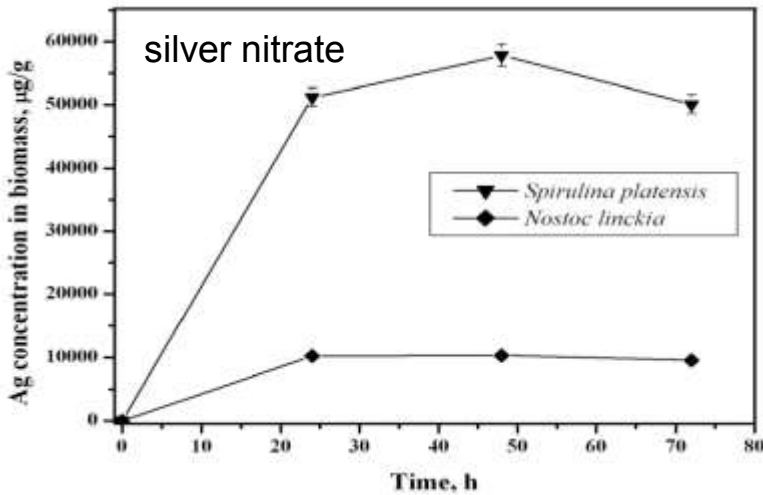
...CREATING OUR FUTURE: Ag nanoparticles



UV-vis Spectrometry, SEM, EDAX, XRD, NAA
Biochemical analysis of biomass components (protein content, phycobiliproteins content, carbohydrates, lipids) antioxidant activity

Institute of Microbiology and Biotechnology of the AS of Moldova

- Cyanobacteria: potential source of novel metabolites that have great importance from a biotechnological and industrial point of view
- Spirulina platensis*: ability to bio-transform and endogenously add the desired essential nutrients, such as Se, I, Cr, etc.
- Nostocaceae*: the most impressive “biochemical factories” of the biological world; valuable source of secondary metabolites, such as antioxidant enzymes, vitamins, etc. used as anti-cancer, anti-HIV, antimalarial, antifungal and/or antimicrobial drugs



- A part of the accumulated silver is converted into nanoparticles mainly formed extracellularly in a spherical form: ≈ 6 nm for *Spirulina* and $\approx 4-5$ nm for *Nostoc*.
- the major reduction of silver concentration in solutions and increase in biomass occurs within the first 24 h.
- While in this time interval minor changes in the biomass took place, a significant reduction of the level of proteins, carbohydrates, phycobiliproteins in both cultures and lipids in *Spirulina platensis* was observed after 48 hours and the antiradical activity of the biomass decreased.

for biotechnological purposes the time of silver nanoparticle synthesis using cyanobacteria should be optimized in order to avoid biomass destruction.

...INVESTIGATING THE ENVIRONMENT: soil pollution

M.V. Frontasyeva, L.P. Strelkova

*Sts. Cyril and Methodius University,
Republic of Macedonia
Geological Survey of Slovenia,*

**State Prize of the Republic of Macedonia
2009**



Critically polluted topsoil

- ❑ AAS (electrothermal + cold vapor system):
Cd, Cu, Pb and Zn
- ❑ NAA: Al, Ca, Fe, K, Mg, Na, Ti, As, Au, Ba, Br, Ce, Co, Cr, Cs, Cu, Dy, Hf, In, La, Mn, Mo, Nd, Ni, Rb, Sb, Sc, Se, Sm, Sr, Ta, Tb, Th, Tm, U, V, W, Yb and Zn
- ❑ the content of elements such as As, Au, Cd, Cu, Hg, In, Pb, Sb, Se, Zn in the soil samples around the Pb and Zn smelter and in the adjacent part of the town of Veles is much higher than in those collected in the surrounding areas due to the pollution from the plant.
- ❑ The enrichment of the elements in the topsoil, compared to the European and Macedonian topsoil is typical for this elemental assemblage, from 2.2-times for Sb to 27-times for Cd.
- ❑ The concentration of any of the mentioned elements (As, Cd, Cu, Hg, Pb and Zn) exceeds the critical value in about 7 km²

T. Stafilov, R. Sajn, Z. Pancevski, B. Boev, M.V. Frontasyeva, L.P. Strelkova
Heavy metal contamination of top soils around a lead and zinc smelter in the Republic of Macedonia
Journal of Hazardous Materials, 175 (2010), 896-914

...INVESTIGATING THE ENVIRONMENT: water pollution

NECSA, Stellenbosch University,
iThemba Labs, South Africa



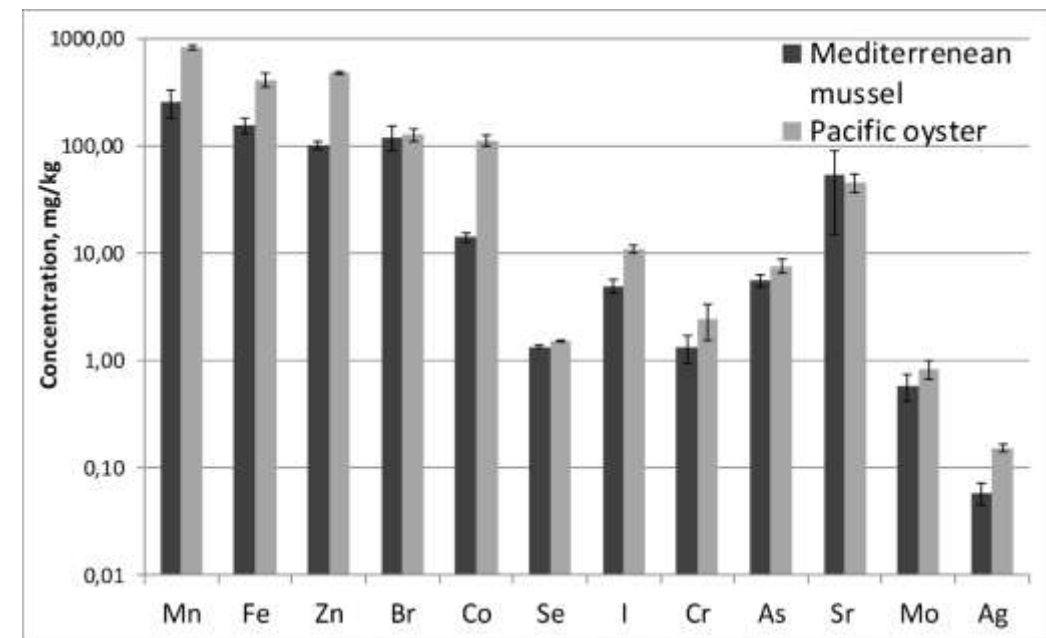
Mediterranean mussels
(*Mytilus galloprovincialis*)
farmed & wild invasive



Pacific oysters
(*Crassostrea gigas*)
farmed

23 trace elements in soft tissue and shell:
Sc, V, Cr, Mn, Fe, Co, Zn, As, Se, Br, Rb, Sr, Mo,
Ag, Sb, I, Ba, La, Ce, Sm, Eu, Hf, Ta)

- The contents of the majority of elements in the soft tissues of both species were higher than those in the shells
- The tissues of wild invasive Mediterranean mussels contain higher levels of a range of trace elements comparing to farmed mussels.
- The tissues of Pacific oysters contain much higher levels of almost all elements studied compared to the tissues of Mediterranean mussels. Higher content of zinc in the mussels and oysters from Saldanha Bay may evidence anthropogenic pollution of the bay's ecosystem by this metal, which necessitates continued monitoring of levels of potentially toxic metals.
- Both alien species, and especially Pacific oysters, may serve as reliable biomonitors for trace elements in marine ecosystems.
- Both species are rich in essential elements and provide nutritionally-valuable seafoods.



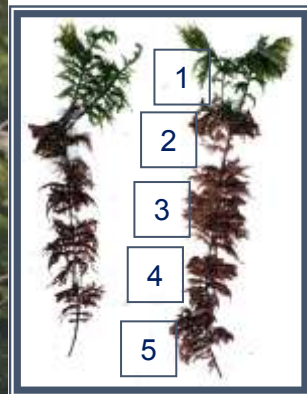
D.F. Pavlov, J. Bezuidenhout, M.V. Frontasyeva, Z.I. Goryainova
Differences in Trace Element Content between Non-Indigenous
Farmed and Invasive Bivalve Mollusks of the South African Coast.
American Journal of Analytical Chemistry 6 (2015) 886-897

...INVESTIGATING THE ENVIRONMENT: air pollution

International Program for the monitoring and evaluation of effects of air pollutants on vegetation (ICP Vegetation), established under the Convention on Long Range Transboundary Air Pollution by Economic Commission for Europe (UNECE)

Priority LRTAP Convention (see Decision 2010/18 and 2011/14)

- Improve ratification and compliance of Protocols by countries in **Eastern Europe, the Caucasus and Central Asia and South-Eastern Europe** to improve air quality
- Increase participation and activities of all Convention Bodies (including ICP Vegetation) in those countries
- Hence, decision to transfer coordination European moss survey to JINR
- Results will be reported to ICP Vegetation Task Force



Status map 2007

Participation to moss survey

HM: 34 (25); N: 12 (15); POPs: 8 (6) - In brackets: 2010/11 survey

Rest of Europe (15)		SEE Europe (8)	EECCA (9)	Others (2)
Austria ^{N,POPs}	Norway ^{POPs}	Albania	Armenia	Canada ^{N,POPs}
Czech Rep.	Poland ^N	Bulgaria	Azerbaijan	Mongolia
Estonia ^N	Slovakia	Greece	Belarus	
France ^N	Spain	Macedonia	Georgia	
Germany ^{N,POPs}	Sweden ^{N,POPs}	Romania	Kazakhstan	
Iceland	Switzerland ^{N,POPs}	Serbia	Moldova	
Ireland ^{N,POPs}		Slovenia ^N	Russian Fed.	
Italy-Bolzano ^N		Turkey	Tajikistan	
Latvia ^{N,POPs}			Ukraine	

^N = also nitrogen data; ^{POPs} = also POPs data

☐ Launch final report at 8th BioMAP¹ workshop in Dubna, July 2018



Project REGATA (1995-2000-2005- 2010-2015-2020)

Title

Heavy metal atmospheric deposition study in selected European and Asian countries using nuclear and related analytical techniques



Participating countries:

Albania, **Armenia**, **Azerbaijan**, Belarus, Bulgaria, Croatia, **Georgia**, Poland, **Romania**, Russia, Slovakia, Greece, **Kazakhstan**, Macedonia, **Moldova**, Mongolia, Serbia, South Korea, Turkey, Vietnam, **Tadjikistan**, Thailand

**China
is very welcome !**

Date: A.M. 1st June. Friday Place: Session B , the Second Floor, Meeting Room 202		Chair: Dr. Yigang YANG
Time	Events	Addressor
08:30-09:00	B10: The Influence of Mineral Fertilizer on the North-Eastern Romania Permanent Grassland as Investigated by Epithermal Neutron Activation Analysis	Prof. Octavian-Gheorghe Dului
09:00-09:25	B11: Evaluation of Anthropogenic and Geogenic Impacts on Marine Sediments of Egyptian Sector of the Red Sea by NAA and ICP-MS	Dr. Wael Ged
09:25-09:50	B12: Study of Major and Trace Elements by the Moss Biomonitoring Technique in Georgia	PhD stud. Omari Chaligava
09:50-10:20	Coffee Break	
10:20-10:40	B13: The Determination of Arsenic Species in Drinking Water Using NAA-k0 Standardization	Prof. Adrian Florinel Bucsă
10:40-11:00	B14: Biosorption of Lead Ions by Cyanobacteria <i>Spirulina Platensis</i> _ Kinetics, Equilibrium and Thermodynamic Study	PhD Stud. Nikita Yushin
11:00-11:20	B15: Result of Investigation of the Isotope Composition of Archaeological Objects by Neutron Resonance Capture Analysis	PhD stud. Nina Bazhazhina
11:20-11:40	B16: The Use of Resonance Neutron Method for Searching of Palladium of the Proton Rocket Engine	PhD stud. Dimitar Grozdanov
11:40-12:00	B17: The Measurements and Applications of Photoneutrons Induced by an Electron Linear Accelerator	Dr. Yigang YANG

Poster session

35	Zinicovscaia I., Pavlov S.S., Frontasyeva M.V., Ivlieva A.L., Petritskaya E.N., Rogatkin D.A., Demin V.A. Study of silver nanoparticles accumulation by mice using neutron activation analysis
36	Yulia Aleksiyenak, O.V. Ignatenko, A.L. Zheludkevich, A.V. Konovalova, V.A. Komar, M.V. Frontasyeva Determination of the impurity composition of copper disulphide obtained under high

	pressure
37	Yulia Aleksiyenak, Marina Frontasyeva Atmospheric deposition of trace elements biomonitoring study at the territory of the republic of Belarus



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Feb. 2002

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苔藓对大气沉降重金属元素 富集作用的研究

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斯坦 O³, 弗罗塔斯耶娃 M V³, 吴鹏程⁴

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2. 北京科技大学 化学系, 北京 100083;
3. 俄罗斯联合原子核研究院 Frank 核物理实验室, 杜布纳 俄罗斯;
4. 中国科学院 植物研究所, 北京 100093

摘要:利用超热中子活化法(ENAA)、原子吸收法(AAS)和原子荧光法(HG-AFS)测定了采自北京远郊和浙江西天目山自然保护区 4 个不同地点 12 种苔藓中 19 个重金属元素含量。结果表明,北京地区大气重金属沉降污染程度远高于浙江西天目山地区。与欧洲苔藓中重金属浓度比较,该 12 种苔藓偏高。经种间校正后的各种苔藓可互相替代作为生物监测器。

关键词:超热中子活化; 生物监测器; 苔藓; 大气重金属沉降
中图分类号: O657.4 文献标识码: A



Thank you!

Welcome to Dubna!

