Environmental Studies in the Nile River Basin Using Nuclear and Related Analytical Techniques

By

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Presentation content

- Introduction
- Aim of the work
  - Area Features
  - Sample Collection and Preparation
- Methodology
  - Neutron Activation and Analytical Techniques
  - Statistical Analysis
- Results and Discussions
  - Contents of contaminants in soil
  - Data Processing
- Conclusions

PROJECTS

- **1st Phase**
  - **Assessment of the environmental situation in the basin of the River Nile using nuclear and related analytical techniques (2011-2014).**
- **2nd Phase**
  - **Environmental studies in Egypt using neutron activation analysis and other analytical techniques (2015-2018).**

INTRODUCTION

- Object?
- Why?
- What?
- Where?
- How?

OBJECT? NILE RIVER AND DELTA

- The Nile River is an artery for Egypt because of its being the main source of fresh water for all forms of life. The Greek Historian Herodotus said about the Nile that; ***"Egypt is the gift of the Nile"***
- the Nile River was key to the development of the Egyptian civilization. Egypt's dependence on a river as its life source was not unique. This dependence was characteristic of several ancient races, including the Mesopotamia and Indus civilizations who relied on the Tigris/Euphrates and Indus rivers respectively.
- This could explain the high interest of many scientists to study the Nile River for different aspects such as geology, geography, agriculture and aquaculture. Scientists have studied the distribution of minor, major and trace elements in the Nile valley and Nile River banks where the most populated areas.

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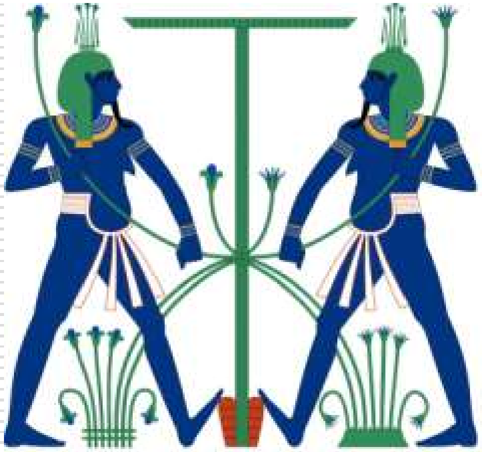
- The Nile River is one of the longest rivers in the world, it flows through 11 countries. Due to geological peculiarities the major source of sediment of the Nile Basin is located in the Ethiopian Plateau where 85% of the Nile water comes from. Originating from Lake Tana (Ethiopia) and Lake Victoria (Kenya, Uganda and Tanzania), the Nile empties into the Mediterranean Sea, forming the Nile delta.

WHY The Nile River ?

- In addition to the previous reasons, Nile river played a vital role in ancient Egyptians' life even in their religion. Although the Nile was directly responsible for either good or bad fortune experienced by the Egyptians, they did not worship the Nile itself. Rather, they thanked specific gods for any good fortune. The most famous Gods related to Nile are Hapi and Osiris



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5000 years later

WHAT, are we seeking for?

- The main goal of the current research is to determine sources of pollution in the basin of Nile river and its Delta.
- Determination of the content in mg/kg the minor, major and trace elements in soil and sediment as a monitor of pollution.
- Base-line information for constructing an ecological map of Egypt, predictions and actions.

WHERE was the present work done?

- A total of 239 samples were collected along the Nile River and its Delta till 2015 (1^{st} phase) and a total of 81 samples from the end of 2015 till now (2^{nd} phase) . Only 40 soil and sediments samples were used for the 1^{st} paper and 10 samples from Siwa Oasis for the 2^{nd} paper.

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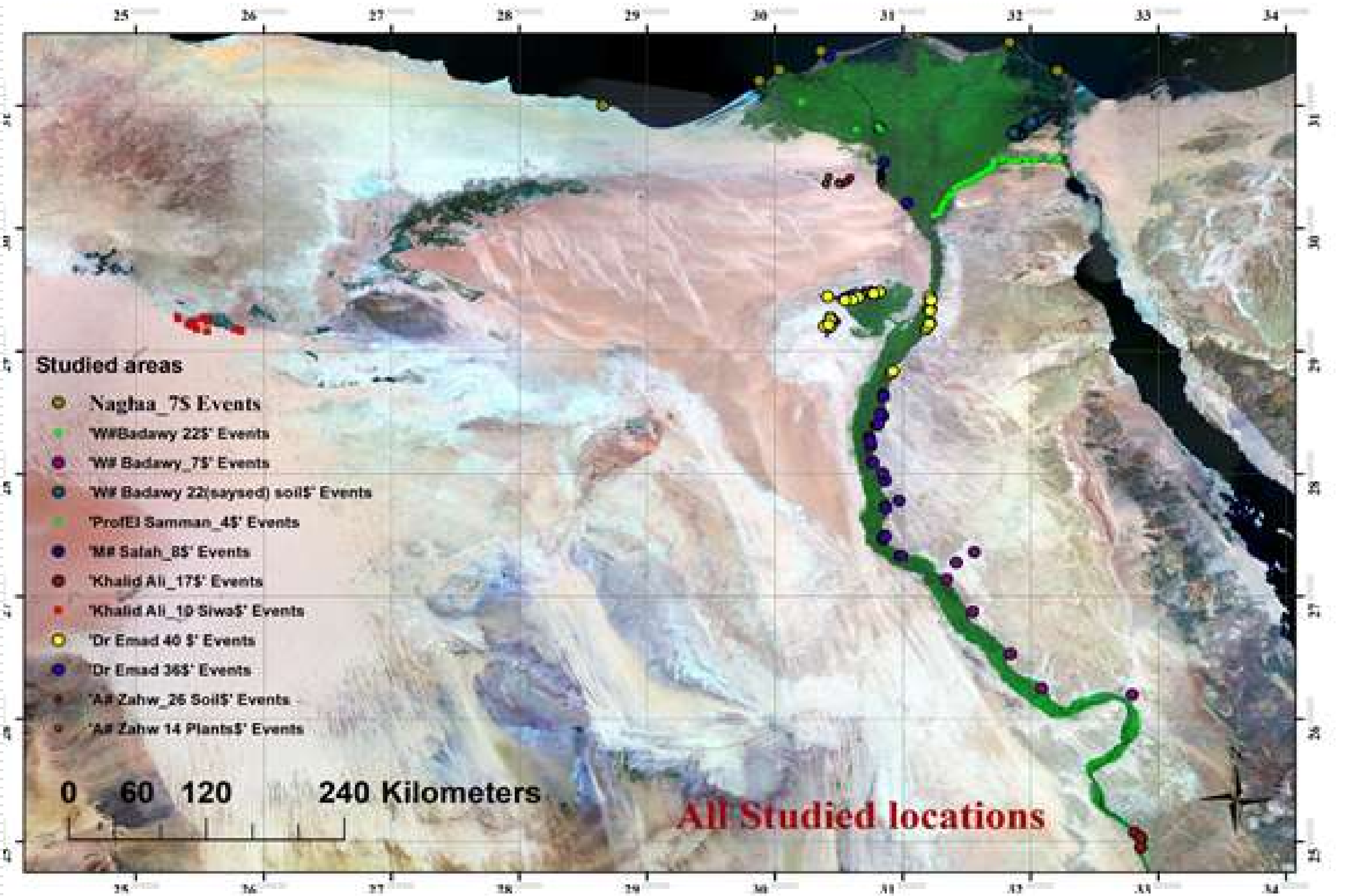
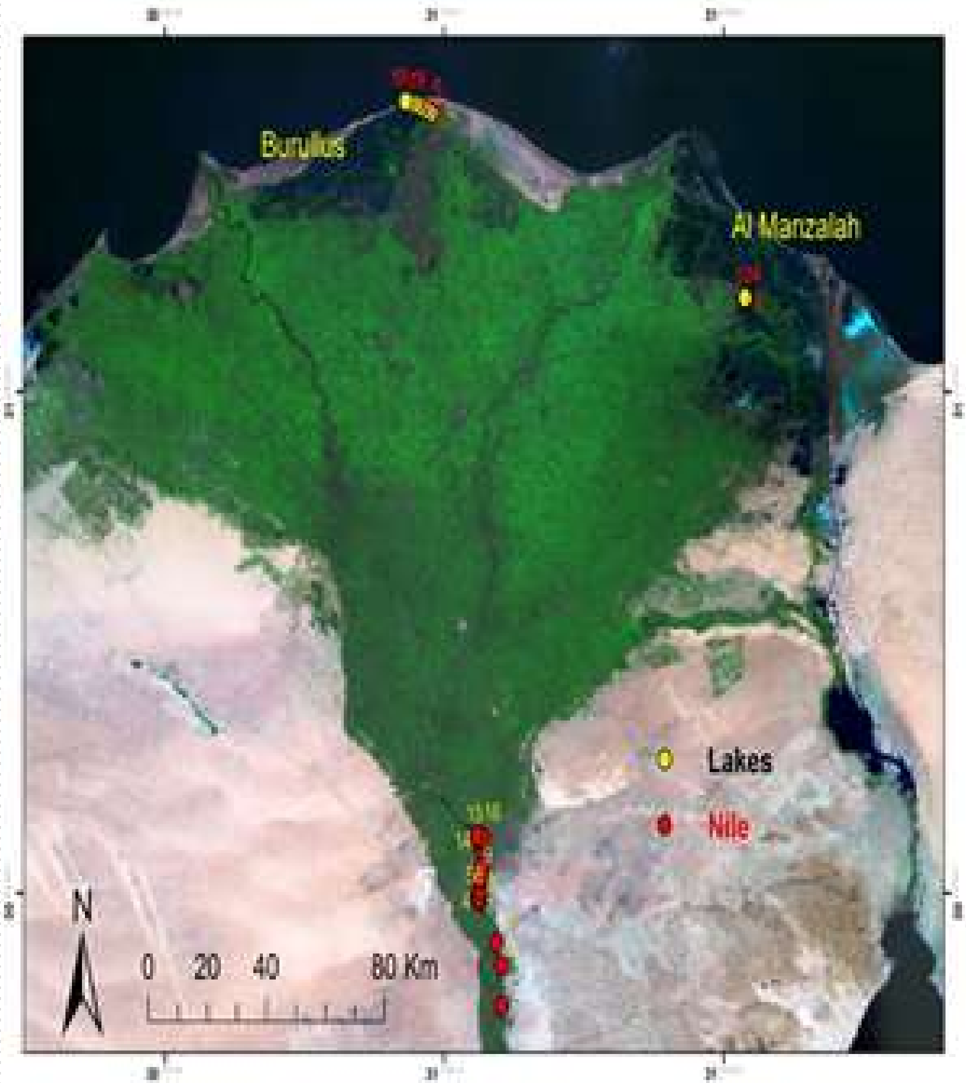
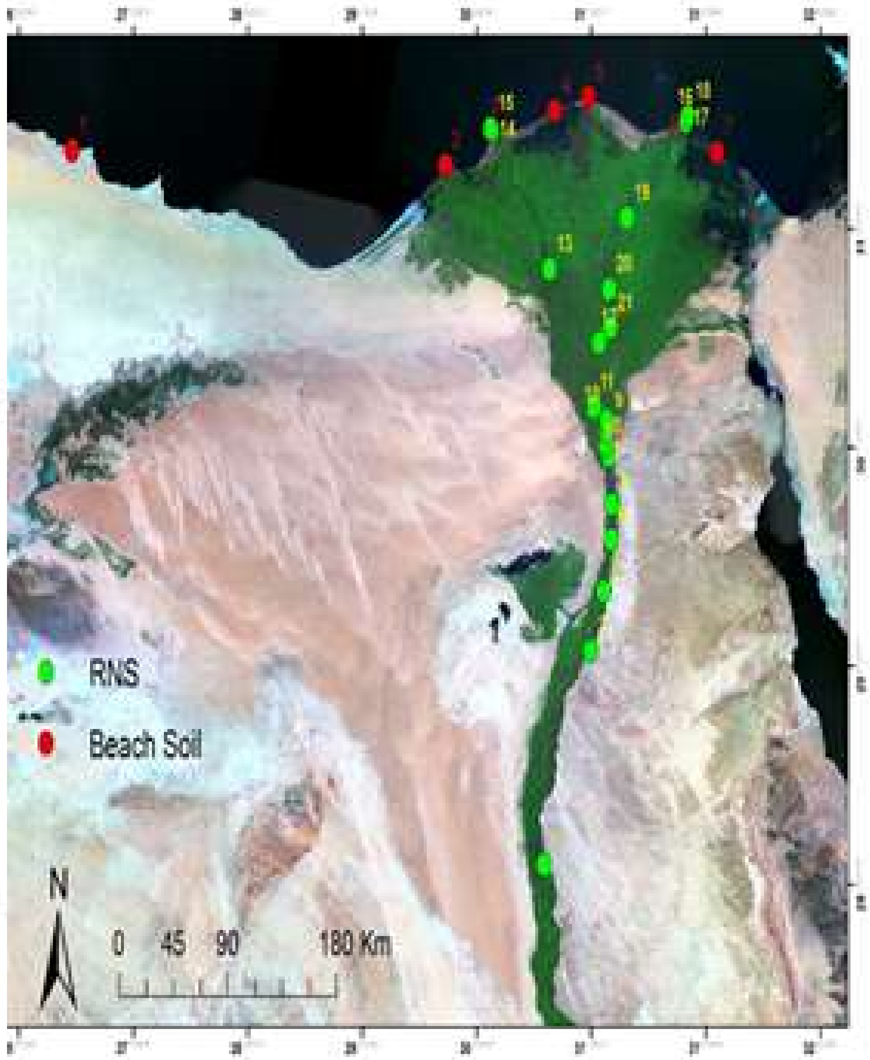
All the studied localities (1st phase)



Studied and proposed localities (2^{nd} phase)





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Collection of Sediments and Soil Samples

Preparation of Collected Samples

- In Egypt:
  - Samples of 1 kg of riverbank surface soil and shallow water sediments were collected in the Delta area and along the Nile valley starting from the **High Dam** in the Upper Egypt to Alexandria in the Lower Egypt.
  - Sampling procedures followed IAEA TECDOC-1415 and recommendations of the Egyptian Geological Survey and Mining Authority (Soil sampling for environmental contaminants, 2004).
  - The samples were air-dried and cleaned from roots of plants and other wastes. Samples were dried to constant weight, ground, and homogenized using an agate ball mill.
  - Samples of about 100 g of samples were zip-packed.

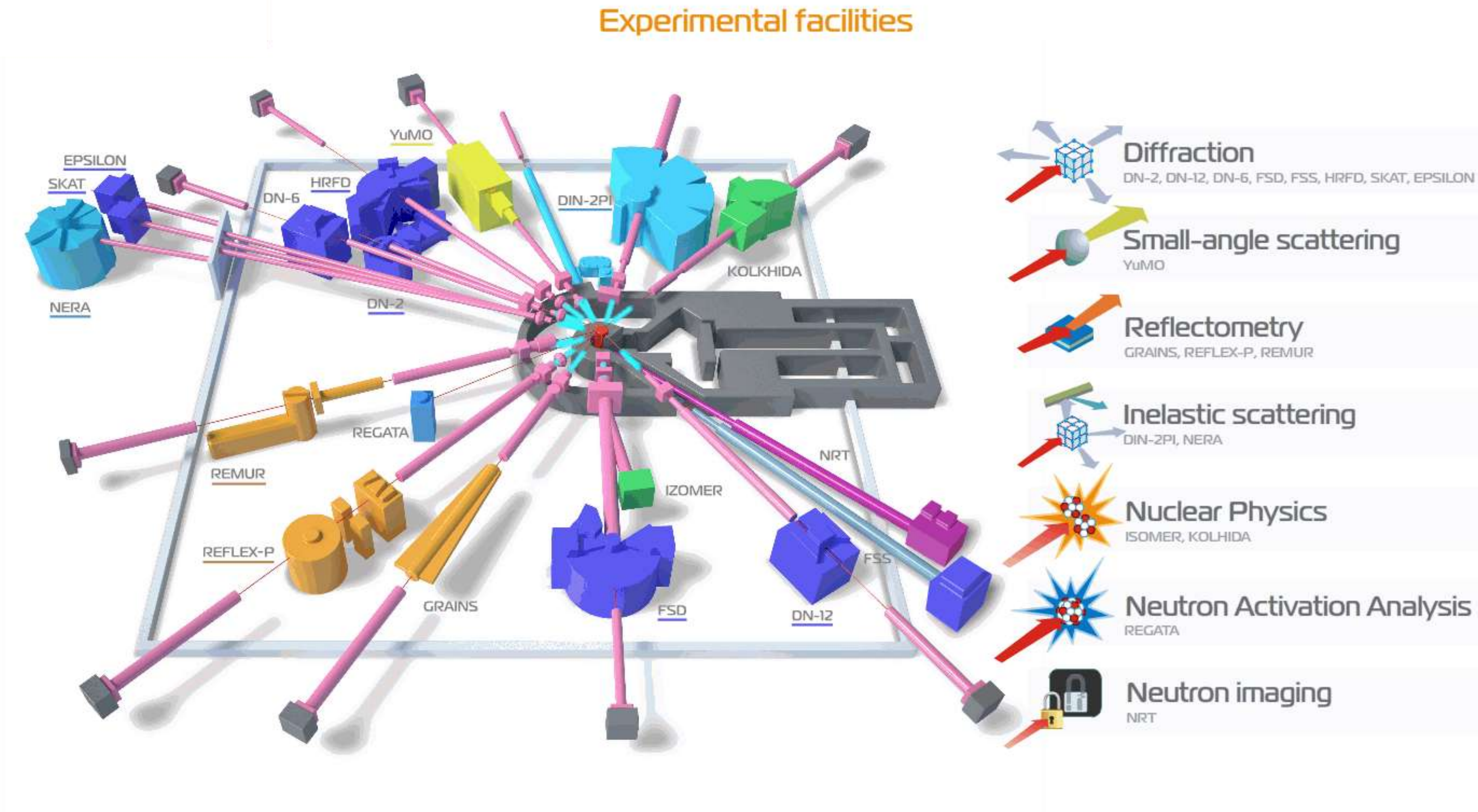
In **Dubna – JINR – SNAAAR**

- Irradiations were preformed at Frank Laboratory of Neutron Physics of the Joint Institute of Nuclear Research at the pulsed reactor IBR 2 using epithermal neutrons. Samples of about 100 mg of soil or sediment were wrapped in polyethylene and aluminium foils for short and long-term irradiations, respectively.
- To determine short-lived isotopes, samples were irradiated for 60 s and measured for 15 min. In case of long-lived isotopes, samples were irradiated for 4 days, repacked and measured twice using high purity germanium detectors, after 4–5 days and 20–23 days of decay for 30 min and 1.5 h, respectively.

HOW, did we analyze the collected samples using NAA

For irradiation

IBR-2



Courtesy of Norbert Kučerka

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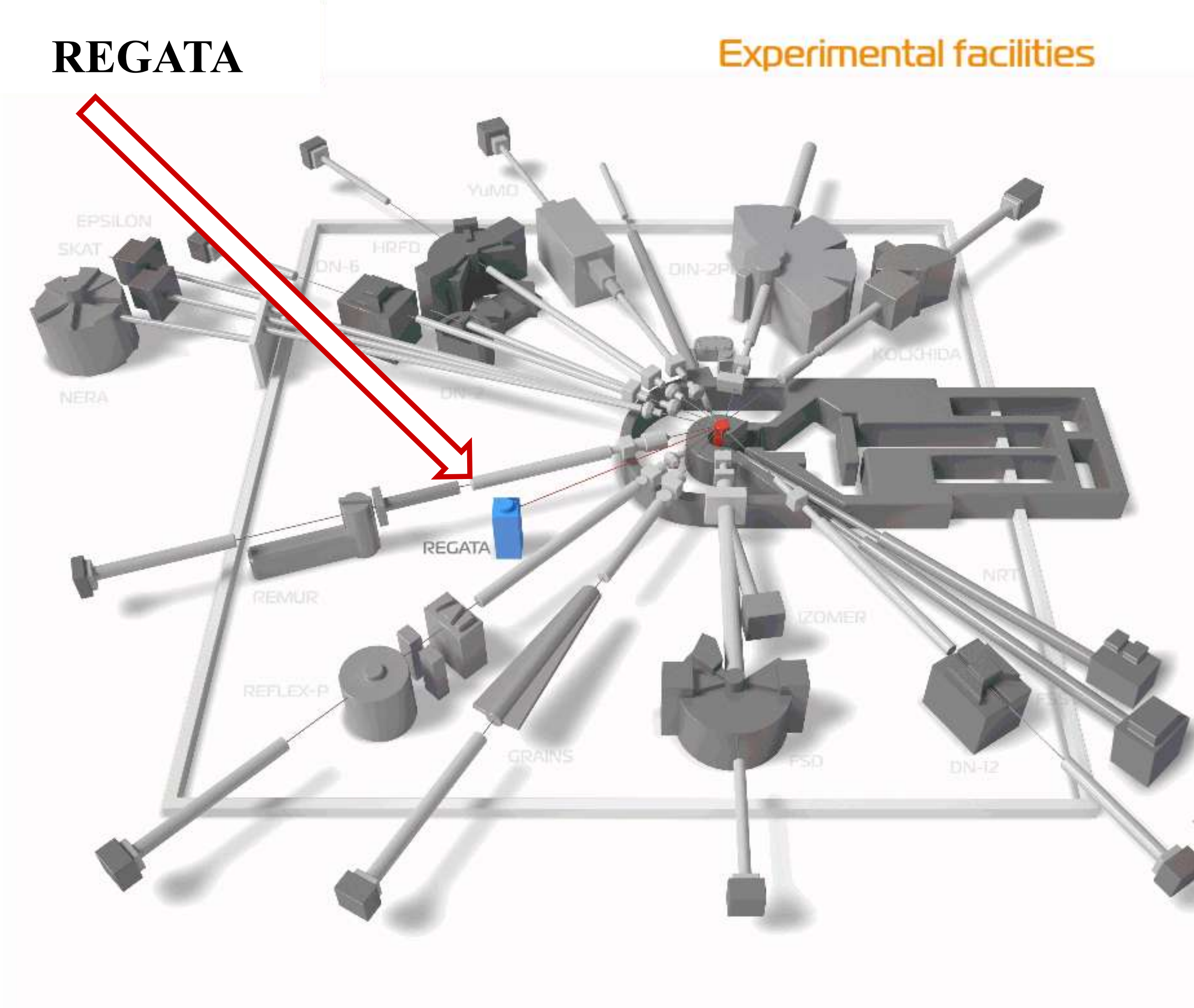
Radioanalytical Complex REGATA

REGATA



Courtesy of Norbert Kučerka

- The accumulated spectra were analyzed for the isotopes radioactivity (µCi/g) using Genie 2000 by Canberra.
- A developed software **CalcConc** at the sector was used to calculate the content of the elements in (mg/kg).
- All calculations were done by means of StatSoftTM Statistica 11 and OriginLabTM Origin 7.5.

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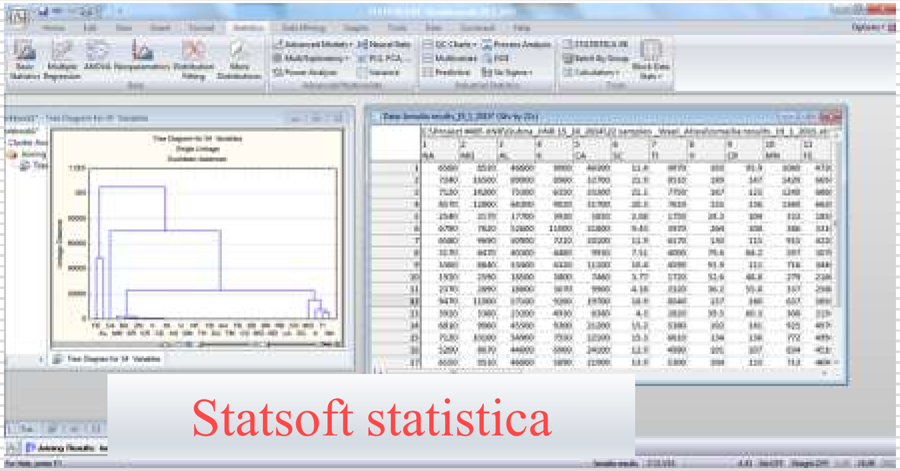
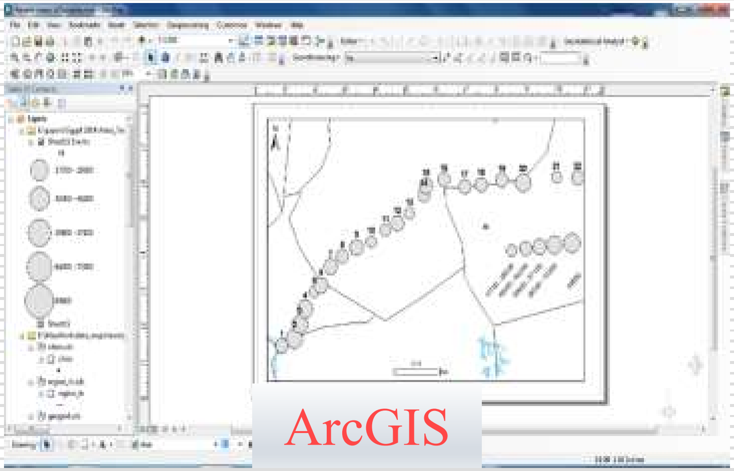
Elements obtained by NAA

H																	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		

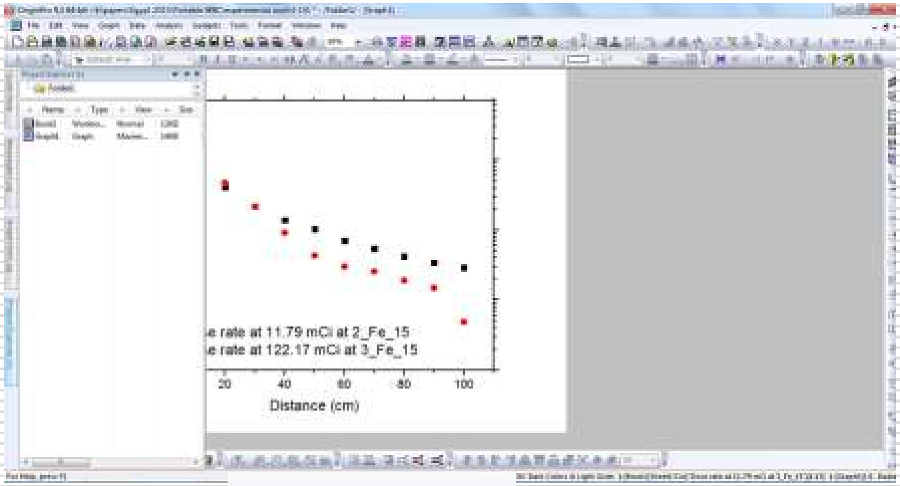
Used Software Packages in Analysis



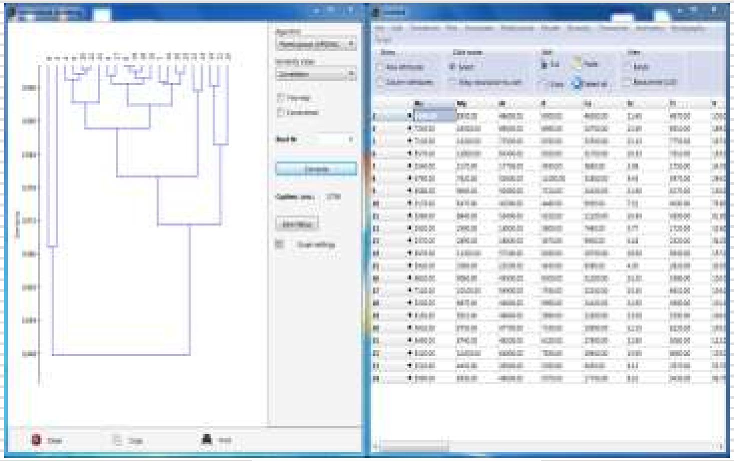
Statsoft statistica



ArcGIS



OriginLab



PAST

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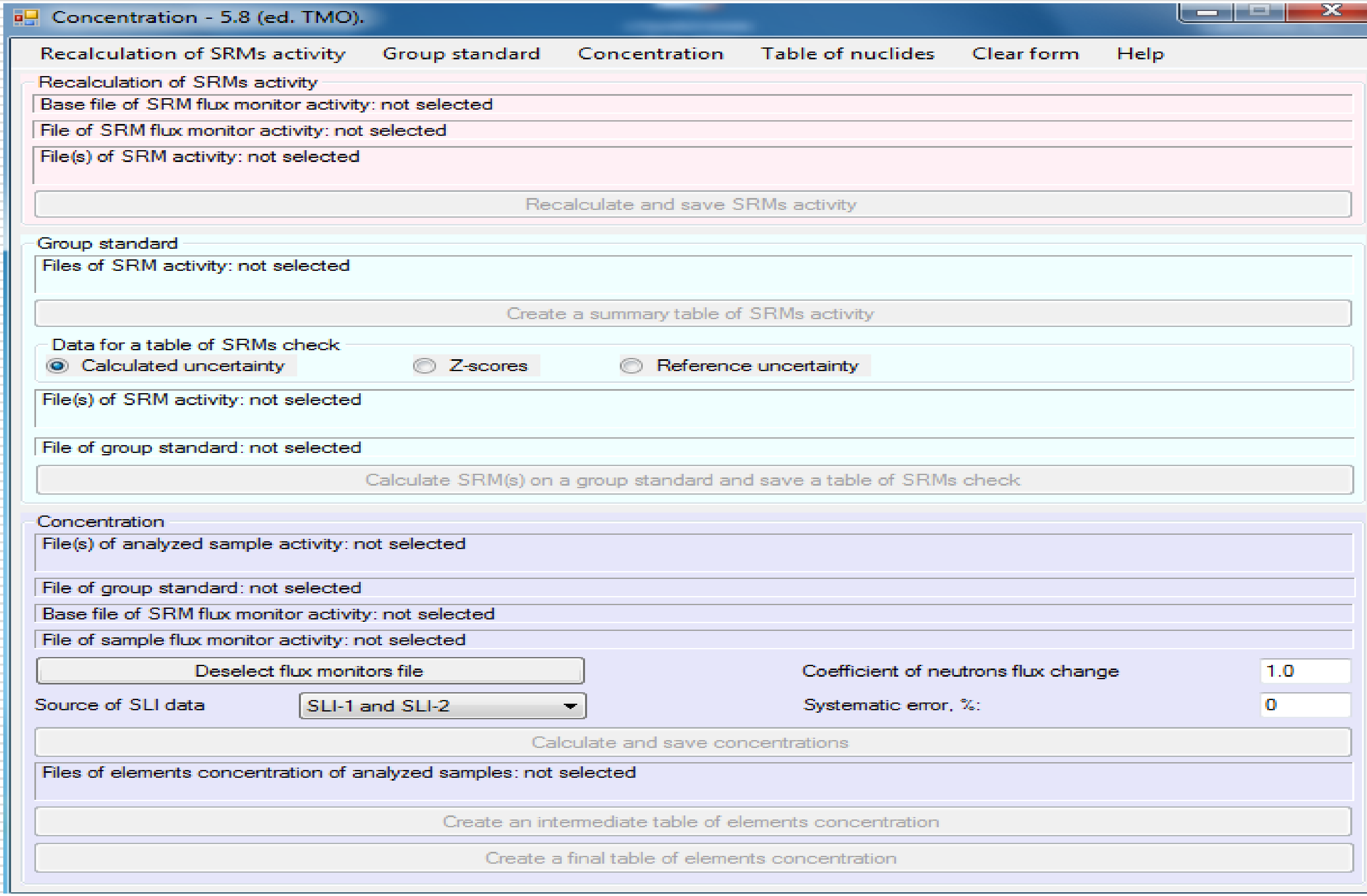
Screenshot of CalcConc Eng. Ver.



OUTCOME, Results and Discussion

- The distributions of 36 major and trace elements in 40 surface soil and sediment samples collected from the Egyptian section of the river Nile were determined by epithermal neutron activation analysis and compared with corresponding data for the Upper Continental Crust and North American Shale Composite.
- A total of 10 samples, were collected randomly from different around Siwa oasis beaches within 5 cm from the earth crust. A total of 35 elements were determined in seven samples of soil, two samples of salty soil, and one of sediments.
- A total of 72 soil and sediment were collected from the central part of Nile River in Egyptian section.

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Mean, median, maximum and minimum values of 36 elements in sediments and soils of the Nile Delta and Aswan–Asyut sector of the Nile valley

Place	Measure	Element											
		Na	Mg	Al	Cl	Ca	Sc	Ti	V	Cr	Mn	Fe	Co
Nile Delta	Mean	8230 (5%)	10,100 (5%)	47,100 (3%)	4720 (10%)	38,100 (5%)	12.7 (10%)	7370 (10%)	130 (15%)	103 (15%)	739 (5%)	3730 (5%)	18 (15%)
	Median	7530	10,400	43,500	2390	32,500	14.2	7890	138	119	716	37,150	20
	St. Dev.	4220	5410	31,500	5700	26,371	5.7	4220	65	51	489	19,600	9
	Max	15,900	26,700	145,000	20,900	113,000	21.9	18,300	272	180	2150	70,200	32
	Min	583	735	2400	600	10,400	3.0	290	7	8	25	8700	5
Aswan–Asyut valley	Mean	5740	9040	37,100	2090	26,400	12.5	5230	89	85	605	34,400	15
	Median	5420	9300	38,200	1250	28,000	13.6	5010	95	90	592	35,700	17
	St. Dev.	5130	6500	24,400	2250	12,500	6.6	3360	62	37	460	18,600	9
	Max	15,400	20,300	74,100	9100	48,500	23.3	10,000	184	164	1590	63,100	30
	Min	302	349	1190	89	4280	2.8	212	3	31	17	6100	2
	t test	1.673	0.557	1.125	1.906	1.795	0.137	1.776	2.085	1.326	0.890	0.478	0.906
	p	0.103	0.580	0.267	0.063	0.080	0.892	0.084	0.044	0.194	0.379	0.635	0.371
Dekov et al. (1997)		nd	nd	nd	nd	28,900	nd	8320	245	191	940	44,100	nd
Viers et al. (2009)		7100	12,600	87,200	nd	25,900	18.2	4400	129	130	1700	58,100	22.5
UCC		25,400	11,600	78,300	150	31,500	14	3300	140	69	770	41,700	17
NASC		1370	1334	67,000	nd	25,900	30	4196	130	125	nd	14,100	26

Place	Measure	Ni	Zn	As	Br	Rb	Sr	Zr	Sb	I	Cs	Ba	La
Nile Delta	Mean	43 (15%)	63 (10%)	5.3 (15%)	122 (10%)	27 (15%)	331 (10%)	331 (10%)	0.18 (5%)	7.4 (20%)	0.81 (15%)	332 (10%)	19.9 (15%)
	Median	44	62	3.2	99	28	263	299	0.17	7.5	0.85	337	17.5
	St. Dev.	24	33	4.5	104	10	222	173	0.09	4.1	0.43	126	6.7
	Max	85	122	16.0	410	43	1040	787	0.30	15.5	1.66	549	33.0
	Min	8	16	0.9	1	8	93	119	0.05	0.6	0.12	90	9.7
Aswan–Asyut valley	Mean	40	62	7.1	190	29	215	266	0.16	5.0	0.95	296	23.6
	Median	42	59	6.3	203	28	214	201	0.11	5.1	0.80	326	22.5
	St. Dev.	23	34	4.1	151	14	91	185	0.13	3.7	0.54	128	9.9
	Max	76	106	15.6	468	54	428	919	0.60	12.2	2.13	519	40.7
	Min	6	12	1.1	1	9	55	73	0.05	0.2	0.23	96	6.7
	t test	0.498	0.083	−1.326	−1.659	−0.460	1.141	2.159	1.446	1.946	−0.892	0.916	−1.385
	p	0.621	0.934	0.193	0.105	0.648	0.261	0.041	0.157	0.059	0.378	0.366	0.174
Dekov et al. (1997)		34	59	nd	nd	45	400	nd	nd	nd	nd	nd	nd
Viers et al. (2009)		74.5	208	35.3	21.5	78.5	187	160	2.19	nd	6.25	522	37.4
UCC		55	67	1.6	2.1	110	350	170	0.2	0.5	3.7	570	30
NASC		58	2.7	nd	70	125	142	200	7.3	nd	8.5	636	31

		Ce	Nd	Sm	Eu	Tb	Dy	Tm	Yb	Hf	Ta	Th	U
Nile Delta	Mean	34.4 (15%)	23.4 (15%)	3.86 (10%)	1.70 (15%)	0.60 (15%)	4.37 (20%)	0.51 (20%)	1.53 (15%)	6.86 (15%)	0.81 (10%)	3.22 (10%)	1.50 (10%)
	Median	32.3	22.8	3.43	1.70	0.60	4.02	0.49	1.50	6.59	0.79	3.00	1.48
	St. Dev.	19.2	7.7	3.20	0.60	0.21	2.91	0.19	0.63	2.12	0.31	0.90	0.45
	Max	64.8	39.9	11.70	2.96	0.92	13.20	0.94	2.81	13.30	1.40	4.69	2.54
	Min	6.4	11.3	0.05	0.89	0.24	0.15	0.27	0.61	4.04	0.32	1.34	0.70
Aswan–Asyut valley	Mean	41.0	18.7	3.20	1.57	0.64	3.61	0.47	1.89	9.02	0.94	4.71	2.45
	Median	40.3	18.7	1.97	1.55	0.62	3.39	0.46	1.70	7.26	0.88	4.60	2.42
	St. Dev.	21.6	7.0	3.91	0.59	0.27	2.65	0.19	0.76	3.90	0.43	1.84	0.89
	Max	77.2	32.2	12.50	2.62	1.06	9.56	1.01	3.24	18.70	1.67	7.84	4.10
	Min	4.2	7.4	0.04	0.76	0.20	0.02	0.15	0.73	4.64	0.24	1.66	0.70
	t test	−1.01	2.03	0.58	0.70	−0.54	0.86	−2.17	−1.64	−2.17	−1.12	−3.26	−4.28
	p	0.317	0.045	0.565	0.491	0.591	0.396	0.036	0.108	0.036	0.267	0.003	0.000
Viers et al. (2009)		73.6	32.2	1.29	0.82	4.25	0.38	2.11	4.04	1.27	12.1	3.3	73.6
UCC		58	26	1.1	0.6	3.5	0.32	2	4	1.5	11	2.8	58
NASC		10.8	27.4	0.7	0.5	nd	0.41	1.9	6.3	0.41	12.3	2.7	10.8

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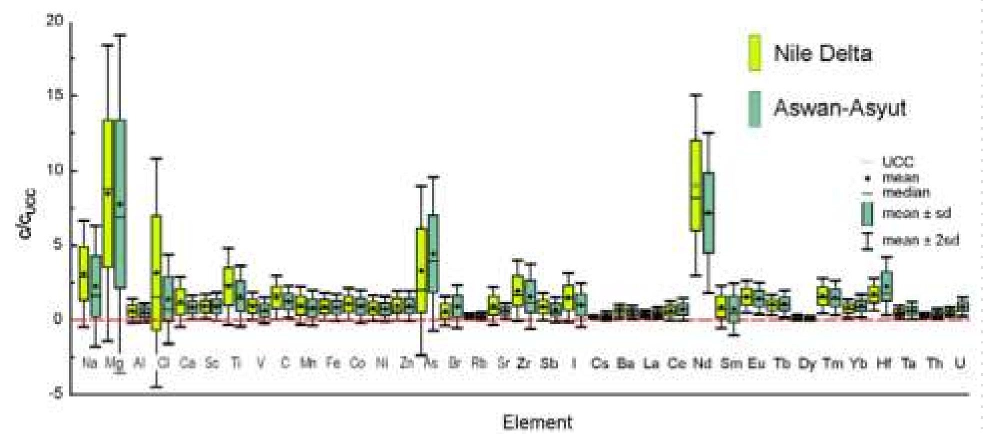
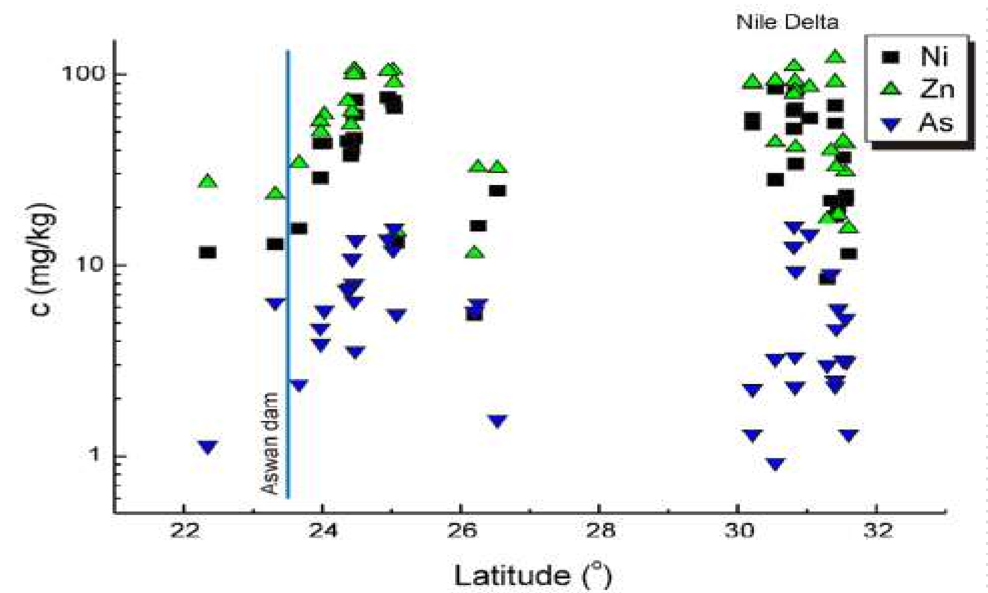
The average contents of Cl and I are higher in sediments of the Nile Delta than in the Aswan–Asyut sector.



No significant differences were observed for these elements between samples from the Aswan–Asyut section of the Nile and the Nile Delta.



- The general distribution of major as well as trace elements may be further elucidated by means of Principal Component Analysis PCA, in both Q and R mode. In the R mode, which considers the distribution of elements (variables) with respect to collecting points (cases) does not provide a clear picture regarding the existence of some cluster, i.e. in spite of their different behavior in environment, seems to be more or less uniformly distributed. The same conclusion could be formulated by analyzing the result of R mode PCA, which prove that all sediments behave more or less uniform, so that any distinct cluster concerning the distribution of collecting points could not be evidenced, SO

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1. Factor 1: Continental rocks
2. Factor 2: Earth crust
3. Factor 3: Marine elements

Element	Factor 1 (48.38%)	Factor 2 (10.27%)	Factor 3 (4.31%)
Na	0.22	0.115	**0.822**
Ni	**0.965**	0.164	0.113
Fe	**0.949**	0.219	0.132
Co	**0.925**	0.137	0.203
Zn	**0.918**	0.284	0.077
Sc	**0.916**	0.255	0.155
Tb	**0.863**	0.448	0.0989
Ce	**0.832**	0.452	0.0794
Tm	**0.825**	−0.073	0.0399
Mn	**0.754**	0.216	0.502
Ba	**0.729**	0.033	0.281
Ta	**0.715**	0.586	0.0293
Cs	**0.713**	0.498	0.04
Dy	**0.704**	0.19	0.5135
La	**0.697**	0.55	0.0627
Al	**0.69**	0.151	0.56
V	**0.679**	0.127	**0.634**
Nd	**0.615**	0.192	0.1805
Ti	**0.613**	0.152	**0.636**
Mg	**0.608**	0.287	**0.654**
Eu	0.522	0.367	0.224
Cr	0.44	0.012	0.235
Th	0.297	**0.876**	−0.042
U	0.199	**0.855**	−0.2006
Yb	0.333	**0.713**	0.1135
I	0.197	−0.002	**0.865**
Cl	−0.201	−0.101	**0.694**

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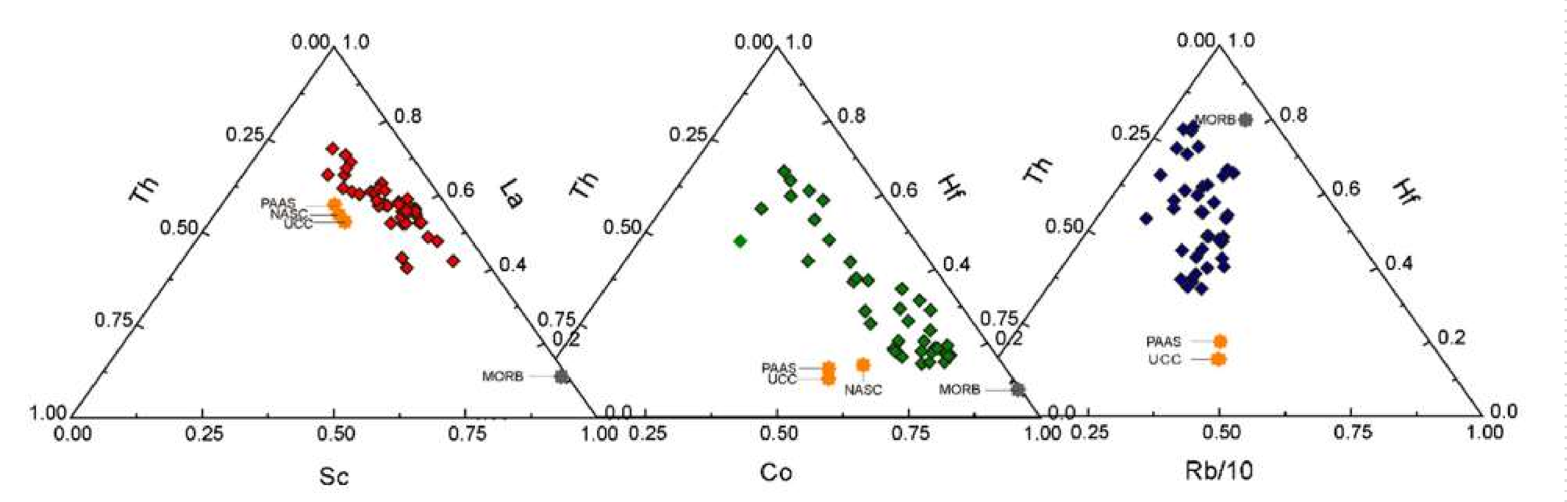

Nile sediments occupy positions that do not overlap with the most common continental average samples, and thus showing a more metabasic origin than sediments from mixed sources because of the presence of more igneous rock detritus than continental ones.

Conclusion

- Using Epithermal Neutrons Activation Analysis we have determined the content of 37 major, rock forming, as well as trace elements in 40 samples of sediments and soils collected from the Egyptian section of the Nile River and covering an area which begun upstream Aswan Dam and finished in the Nile Delta.
- Although collected from a relatively restrained area with respect with the total lengths of the Nile River, the investigated samples furnished interesting information regarding the chemical composition of Nile sediments and soils from the closest vicinity of the river.
- Accordingly, in spite of the fact that the majority of investigated elements present contents close to the Upper Continental Crust, their relative distribution points towards to the presence various debris of igneous rocks, *mostly originated from the Ethiopian Plateau as the Blue Nile transports about 80% of the all Nile sediments*.
- At the same time, the distribution of the potential polluting elements: Ni, Cu, Zn and As *did not present any systematic increases in some regions including the Nile Delta which concentrate about 60% of the Egypt industrial activity, so they could not considered as pollutants.*

Published papers

Journal Metrics

Source Normalized Impact per Paper (SNIP): **1.157**

SCImago Journal Rank (SJR): **0.557**

Impact Factor: **1.403**

5-Year Impact Factor: **1.755**

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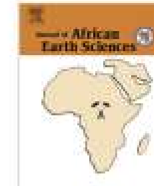

Geochemistry of sediments and surface soils from the Nile Delta and lower Nile valley studied by epithermal neutron activation analysis

CrossMark

Wafaa M. Arafa [a], Wael M. Badawy [b,g], Naglaa M. Fahmi [c], Khaled Ali [d], Mohamed S. Gad [e], Octavian G. Duliu [f], Marina V. Frontasyeva [g,*], Eiliv Steinnes [h]

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RADIOBIOLOGY, ECOLOGY AND NUCLEAR MEDICINE

Instrumental Neutron Activation Analysis of Soil and Sediment Samples from Siwa Oasis, Egypt[1]

Wael M. Badawy[a], Khaled Ali[b], Hussein M. El-Samman[c], Marina V. Frontasyeva[d], Svetlana F. Gundorina[d], and Octavian G. Duliu[c]

SCOPUS, INSPEC, Astrophysics Data System (ADS), Chemical Abstracts Service (CAS), Google Scholar, Academic OneFile, Gale, INIS Atomindex, INSPIRE, OCLC, SCImago, Summon by ProQuest

In process

Sent to layout, J. of Ecological Chemistry and Engineering S; IF = 0.671

Wael BADAWY[1,2*], Olesya Ye. CHEPURCHENKO[2], Hussein EL SAMMAN[3] and Marina V. FRONTASYEVA[2]

ASSESSMENT OF INDUSTRIAL CONTAMINATION OF AGRICULTURAL SOIL ADJACENT TO SADAT CITY, EGYPT

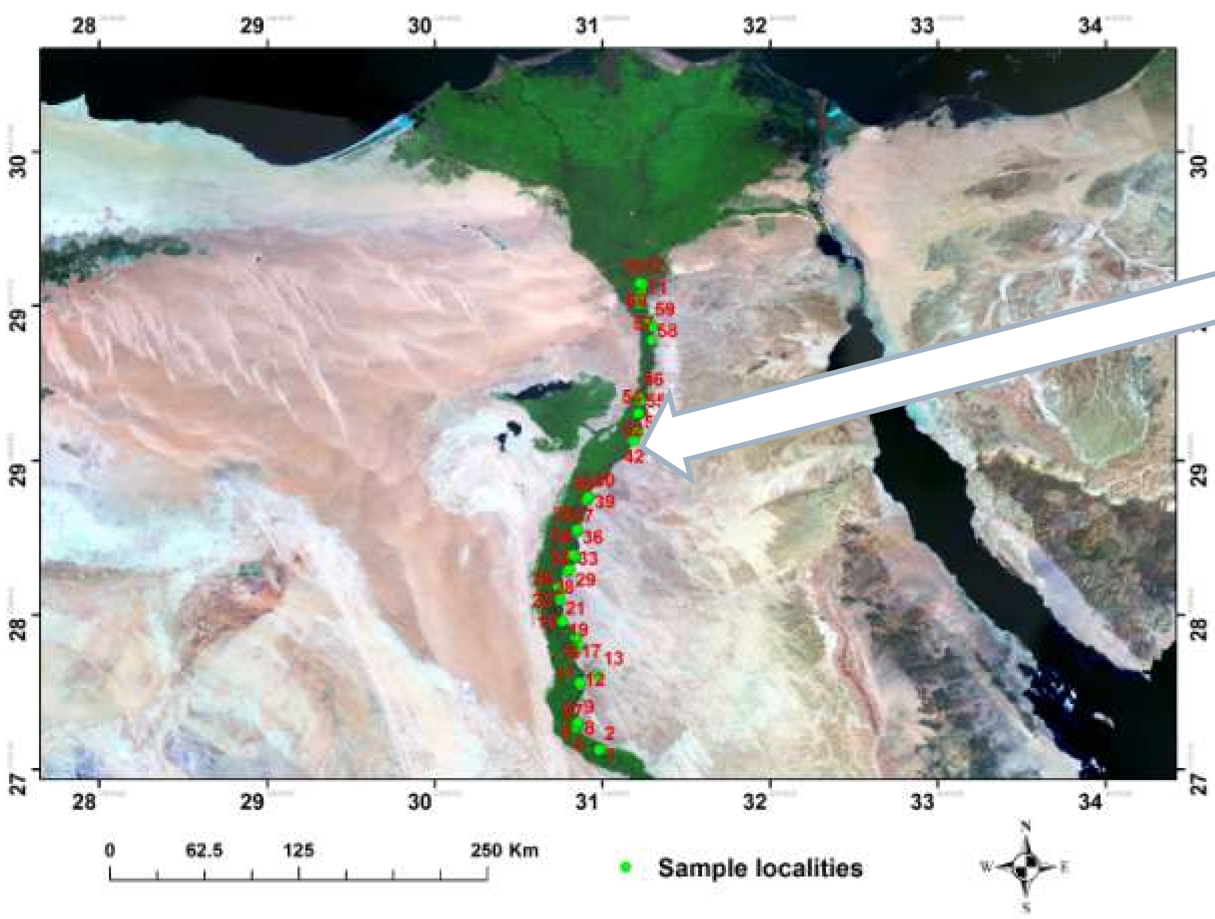
In process

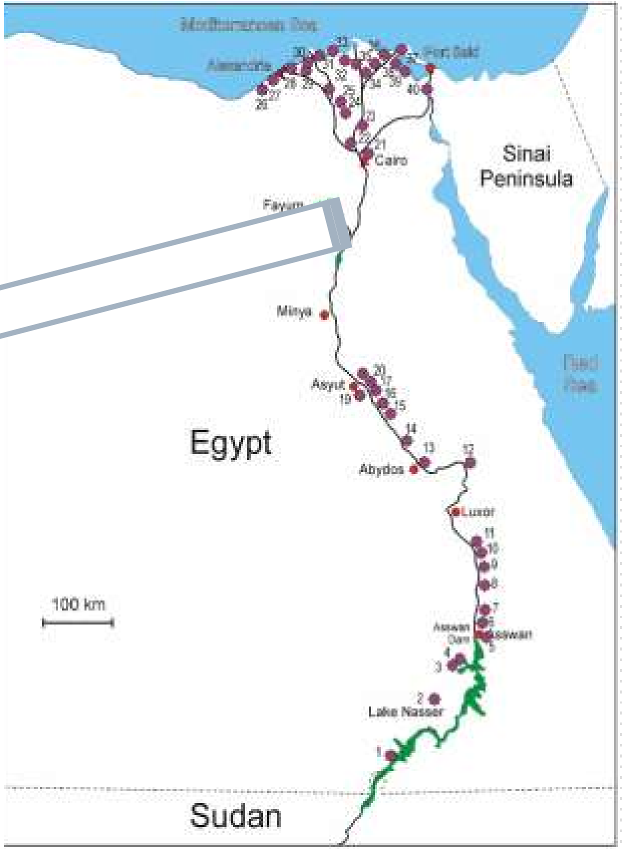
Geochemistry of Sediments and Surface Soils from the Central Nile River of the Egyptian Section Studied By Epithermal Neutron Activation Analysis

By

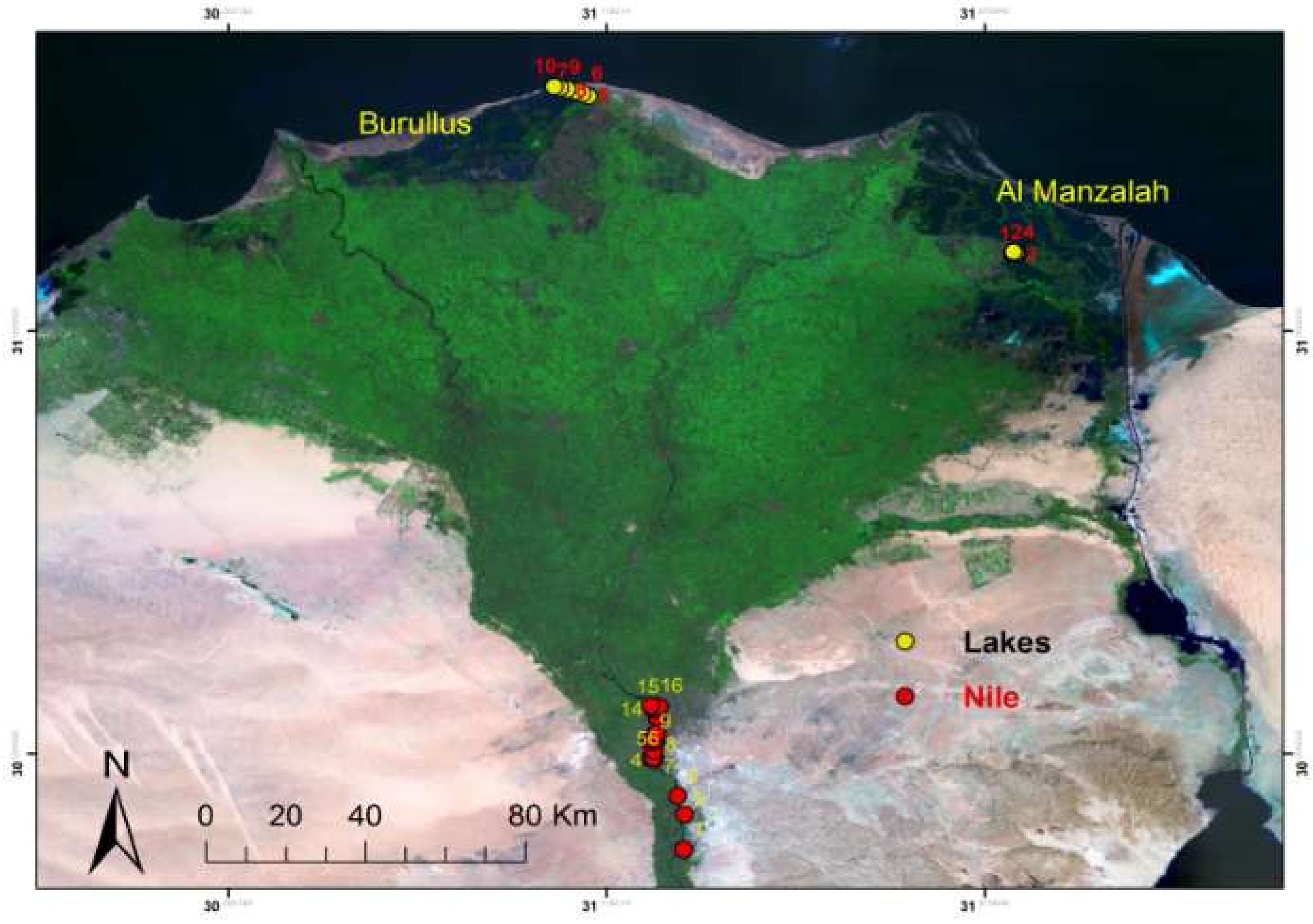
W. M. Badawy[1*], E. H. Ghanim[2], H. El Samman[3], M. V. Frontasyeva[4], and Octavian G. Duliu[5]

Prospective





Lakes and lagoons in Egypt



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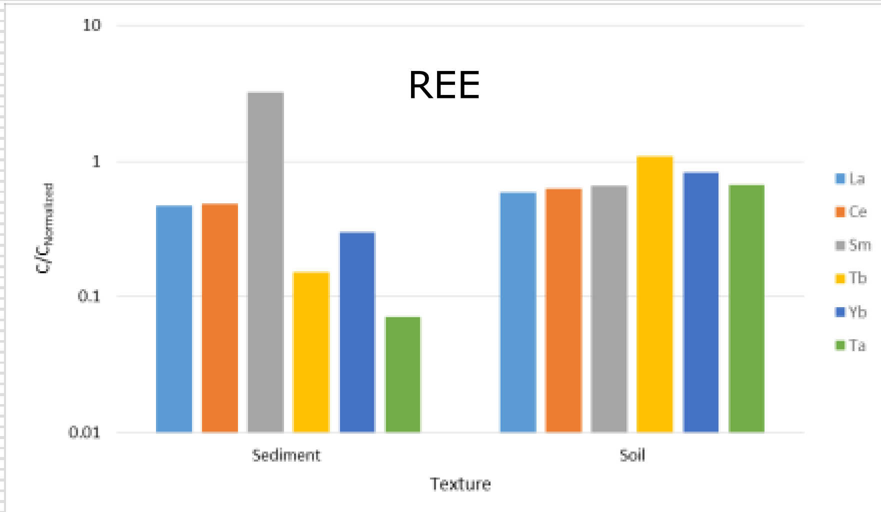
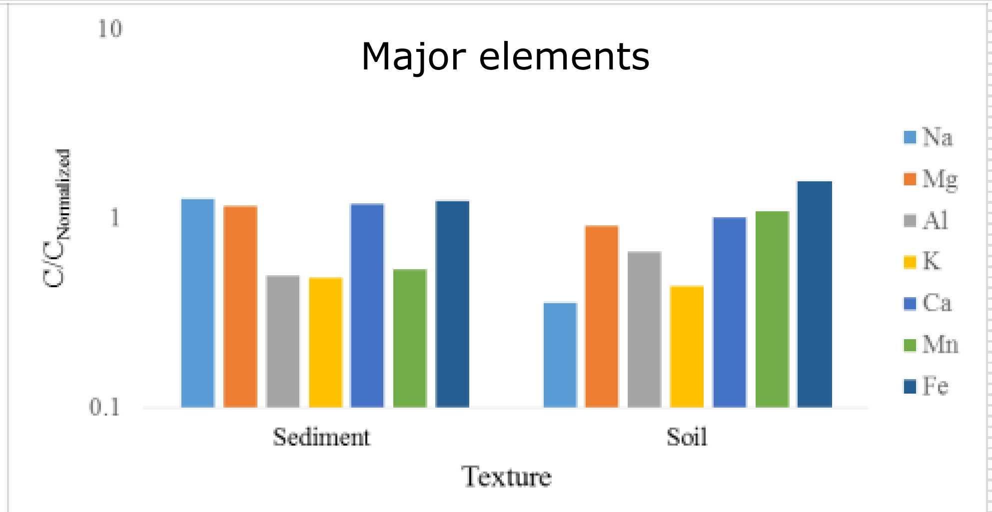
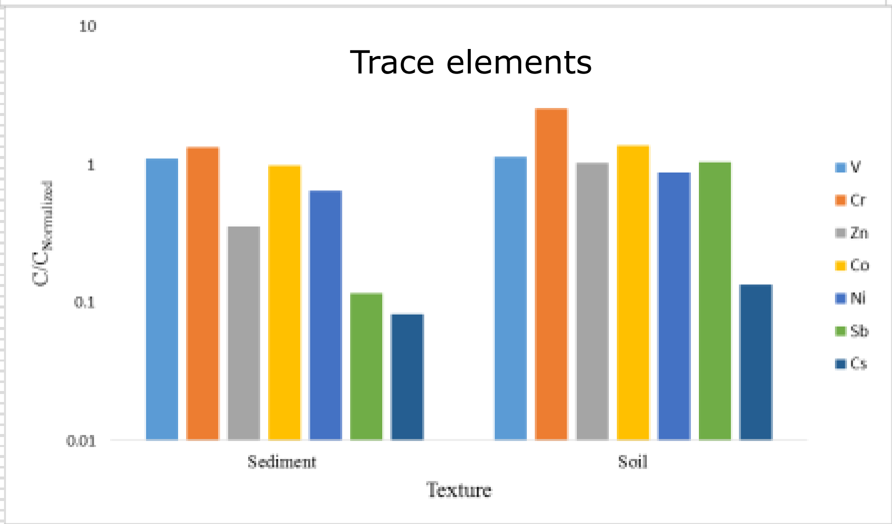
Preliminary findings







It's obvious that there is no significant difference of elements' content in sediments and soil.

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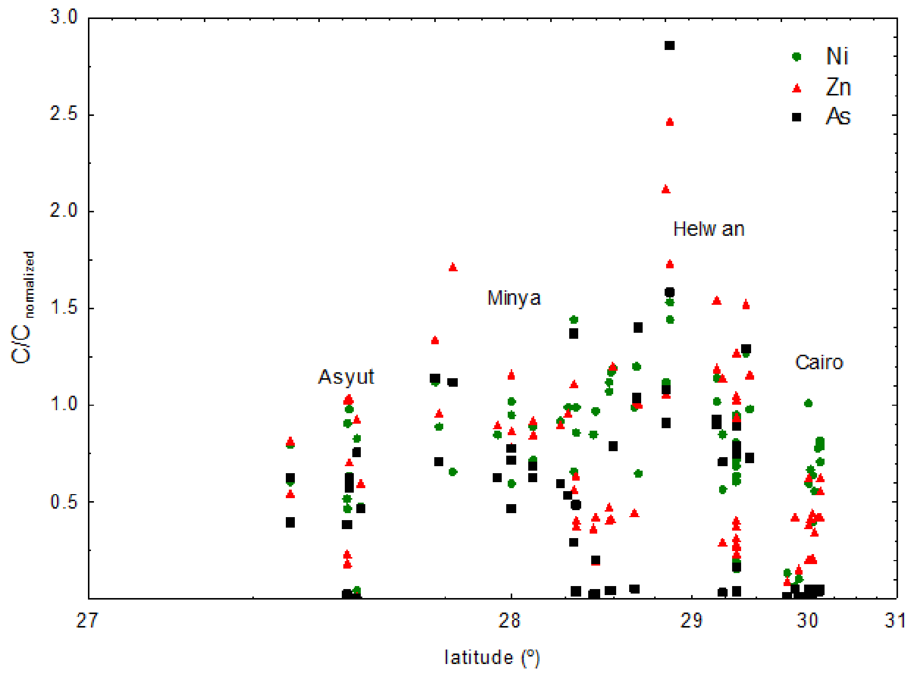
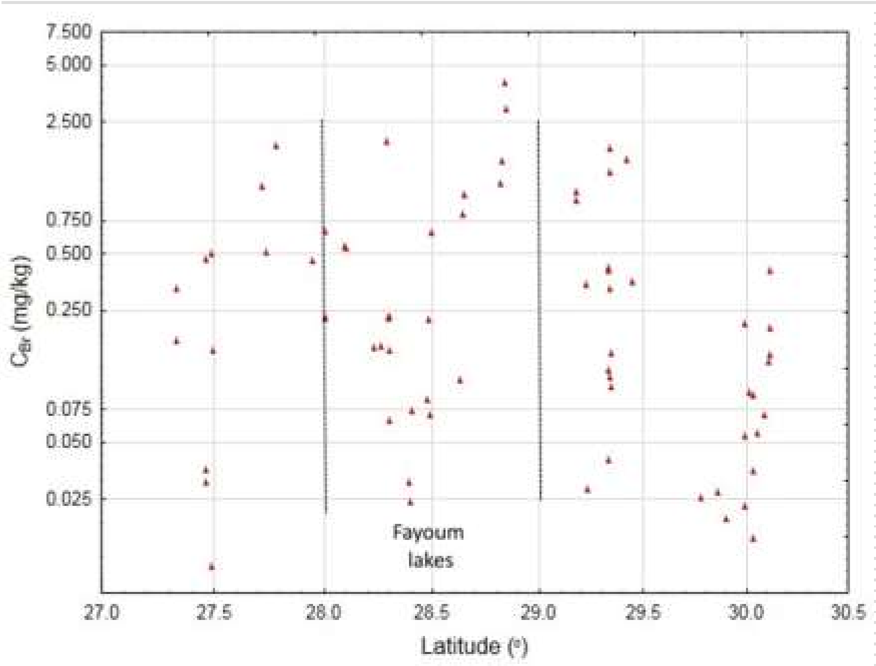


Distribution of Ni, Zn and As with latitude



Content of Br Vs latitude

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There is no wrong answer, but there is an answer that needs a change.