Major and Trace Element Distribution in Soil and Sediments from the Egyptian Central Nile Valley

By

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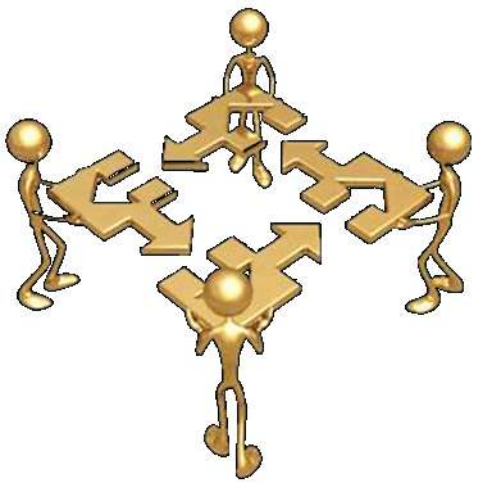
Five W*s* and How!

Three Whats

1. What was done?
2. What is going on?
3. What will be done?

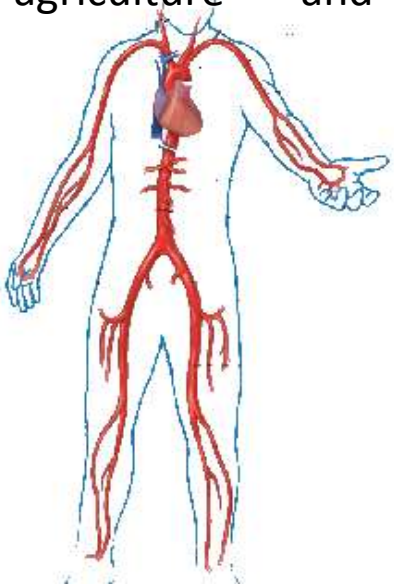
PROJECTS

- **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

- Almost all population 91.6 M lives along the Nile River and Nile Delta.
- The Nile River is an artery for Egypt because of its being the main source of fresh water for all forms of life.
- Trace and major elements in soil and sediments
- Geology, geography, agriculture and aquaculture.



GOALS?

- Bridging the gap.
- Determination of the content (mg/kg) of major and trace elements in soil and sediments.
- Sources of pollution.
- Estimation of Enrichment Factor EF and Geoaccumulation index (I_{geo}).

WORKING SEQUENCES

Sampling → **Sample Irradiation** → **Analyses**

- A total of 72 samples -> 40 soil and 32 sediments.
- Pre-treated in Egypt and prepared to NAA in Russia.
- Irradiated and measured using HPGe detectors

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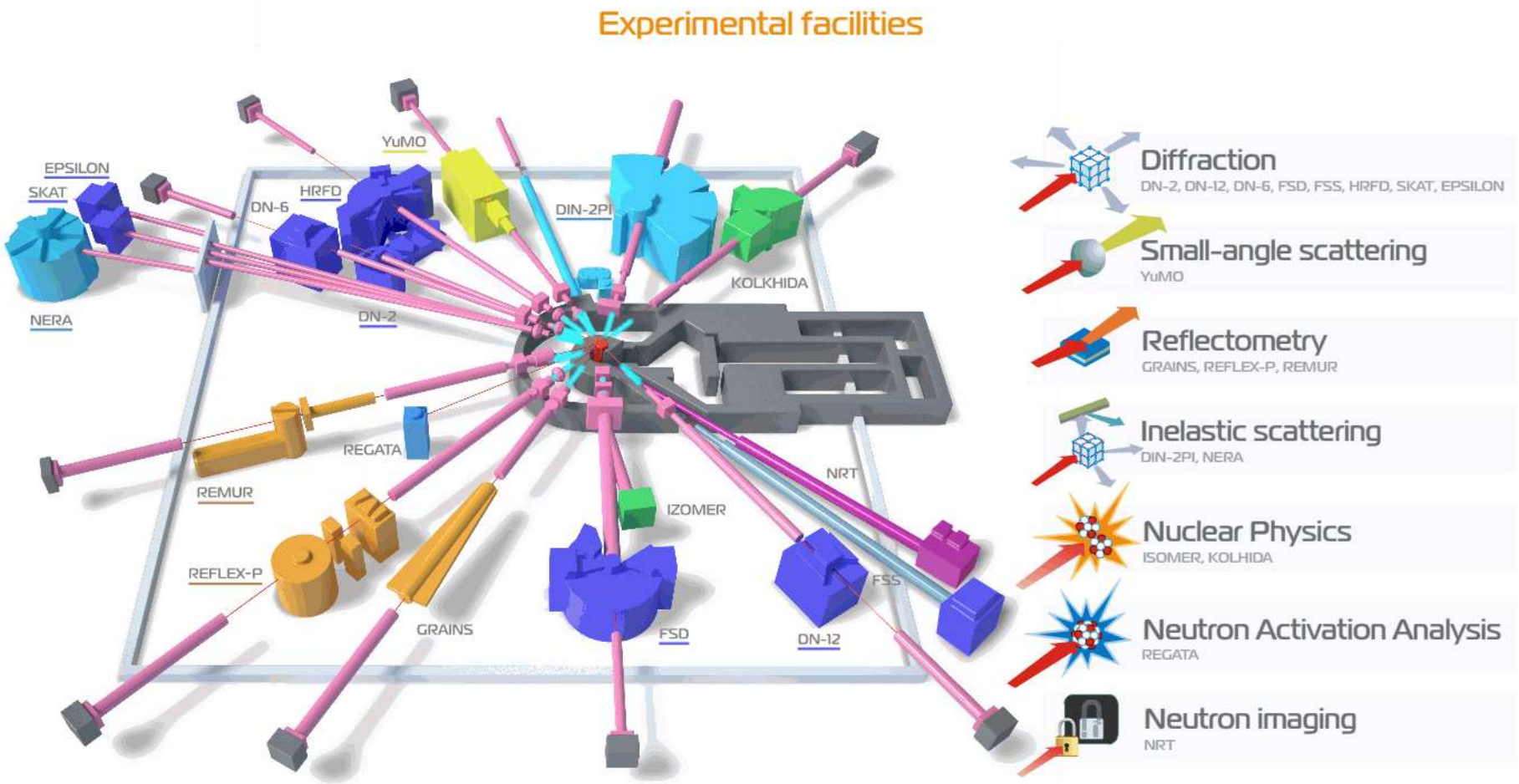
Data processing

- Process of Gamma-ray spectra of induced activity using Canberra G2x.
- Statistical analyses
- Data processing and interpretation

Sampling

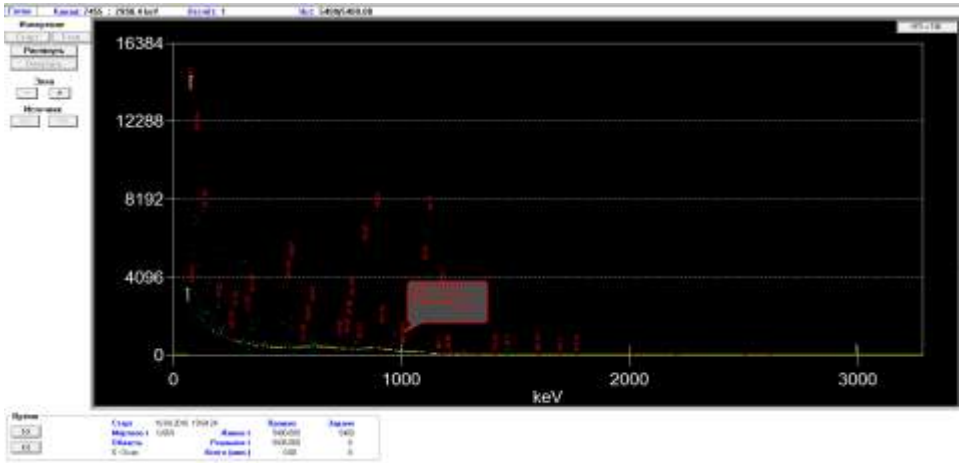
IBR-2

Sample Irradiation



Courtesy of Norbert Kučerka

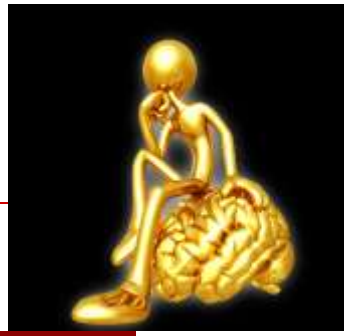
Analyses



- Spectra processing
- Calculation of content

Data processing

Data processing



Statistical analyses

- Descriptive statistics.
- Principal Component Analysis PCA
- Data normality test (Shapiro-Wilk test).

Data interpretation

- Comparison
- Influence of sedimentation
- Distribution of major and trace elements
- Hypothesis
- Knowledge bank for elements
- Calculation of Enrichment factor and geoaccumulation index.

Statistical analyses

Descriptive statistics

Soil

Element	Mean	Median	SD	Min	Max	Congo	Upper Niger	UCC	NASC	WASS	AWS	ANS&S
Na	9114	8760	3409	3510	15400	2590	ND	24250	1370	7100	ND	8230
Mg	10535	10900	2343	2960	14800	ND	ND	14900	1334	12600	ND	10100
Al	52338	54700	11518	22200	72200	ND	ND	83100	67000	87200	ND	47100
K	6560	6505	2677	1600	12200	9100	ND	23245	ND	16900	ND	ND
Ca	31876	32400	6860	15000	45000	25000	ND	25657	25900	25900	ND	38100
Sc	15	16	5	3	22	16.1	ND	14	30	18.2	11.7	12.7
Ti	12885	11100	5647	2040	26500	ND	ND	3837	4196	4400	7038	7370
V	161	160	49	24	266	ND	103	140	130	129	129	130
Cr	176	191	63	33	308	119	153	69	125	130	59.5	103
Mn	836	848	201	179	1140	ND	ND	770	ND	1700	488	739
Fe	45305	45100	11109	9840	65500	78400	ND	39200	14100	58100	ND	37300
Ni	48	50	17	8	84	ND	82	55	58	74.5	29	43
Co	23	25	8	5	36	23.9	24	17	26	22.5	11.3	18
Zn	69	68	30	13	165	ND	90	67	2.7	208	70	93
As	1.3	1.2	0.8	0.3	4.6	ND	ND	1.6	ND	35.3	6.83	5.3
Br	1.7	1.0	1.7	0.2	8.6	ND	ND	2.1	70	21.5	10	122
Rb	28	28	8	5	39	60	64	110	125	78.5	68	27
Sr	288	307	75	56	394	52	117	350	142	187	175	331
Zr	265	257	146	43	790	156	82	162	200	160	267	331
Mo	1.3	0.9	0.9	0.2	4.6	ND	ND	1.6	ND	2.98	1.1	ND
Sb	0.2	0.2	0.2	0.0	0.9	ND	ND	0.2	7.3	2.19	0.67	0.18
Ba	481	498	127	89	661	339	595	570	636	522	460	332
Cs	0.5	0.5	0.2	0.1	1.2	4.4	3.8	3.7	8.5	6.25	5.06	0.81
La	18	18	6	3	30	41.7	47	30	31.1	37.4	27	19.9
Ce	37	36	12	5	62	94.8	97	58	66.7	73.6	56.7	34.4
Sm	3.0	2.4	1.7	0.6	6.9	6.7	6.9	4.59	5.59	1.29	4.6	3.86
Tb	0.7	0.7	0.2	0.1	1.0	0.72	0.72	0.6	0.5	4.25	0.63	0.6
Yb	1.7	1.8	0.8	0.3	3.0	2.6	1.6	2	1.9	4.04	2.6	1.53
Hf	8.1	7.4	3.9	1.6	23.1	4	1.7	4	6.3	1.27	6.4	6.86
Ta	1.0	0.9	0.7	0.2	4.5	1.6	0.8	1.5	0.41	12.1	1.39	0.81
Th	3.3	3.2	1.6	0.5	8.9	13.8	13.3	11	12.3	12.1	9.2	3.22
U	0.8	0.7	0.4	0.2	1.9	2.4	2.5	2.8	2.7	3.03	3	1.5

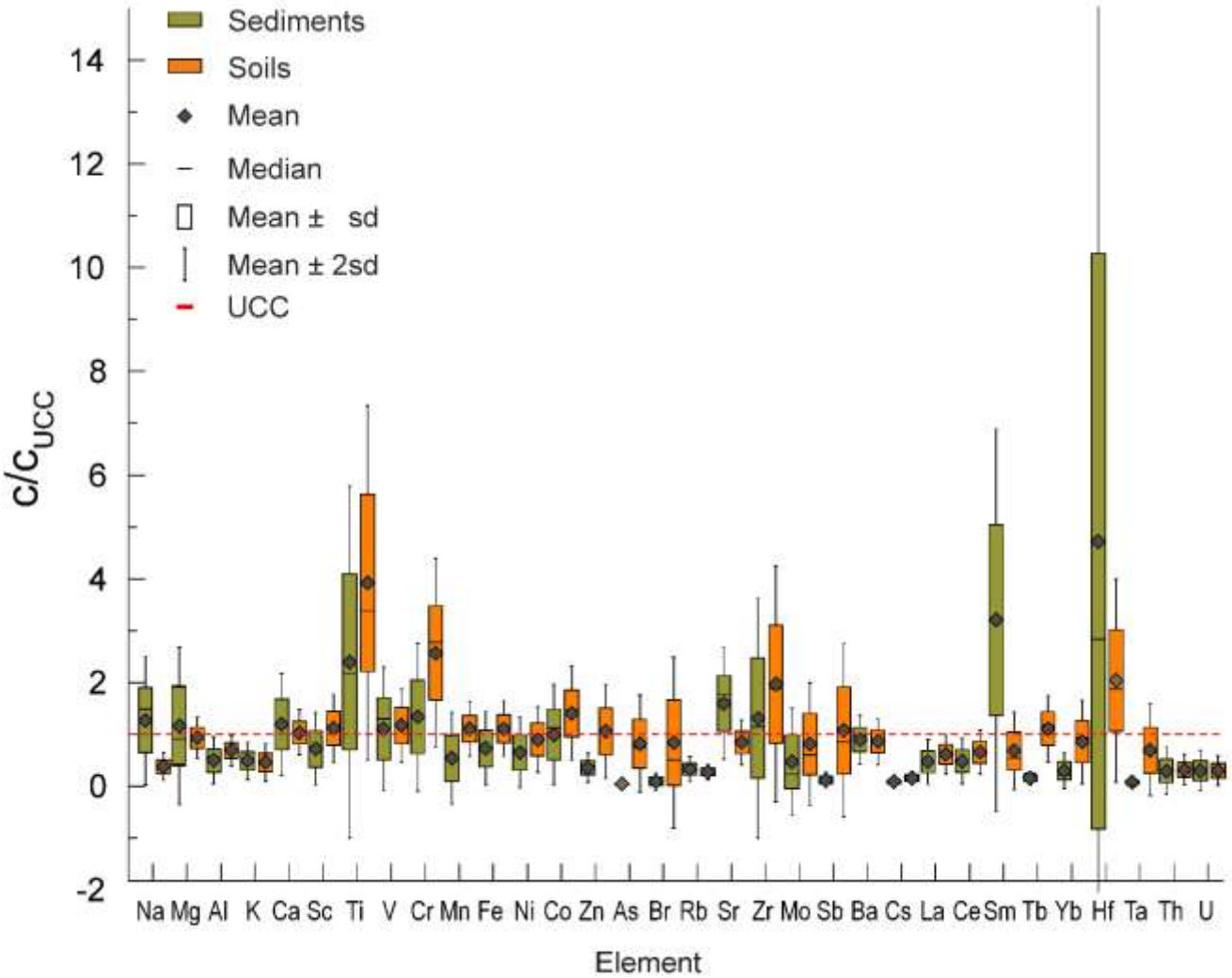
Con't

Sediments

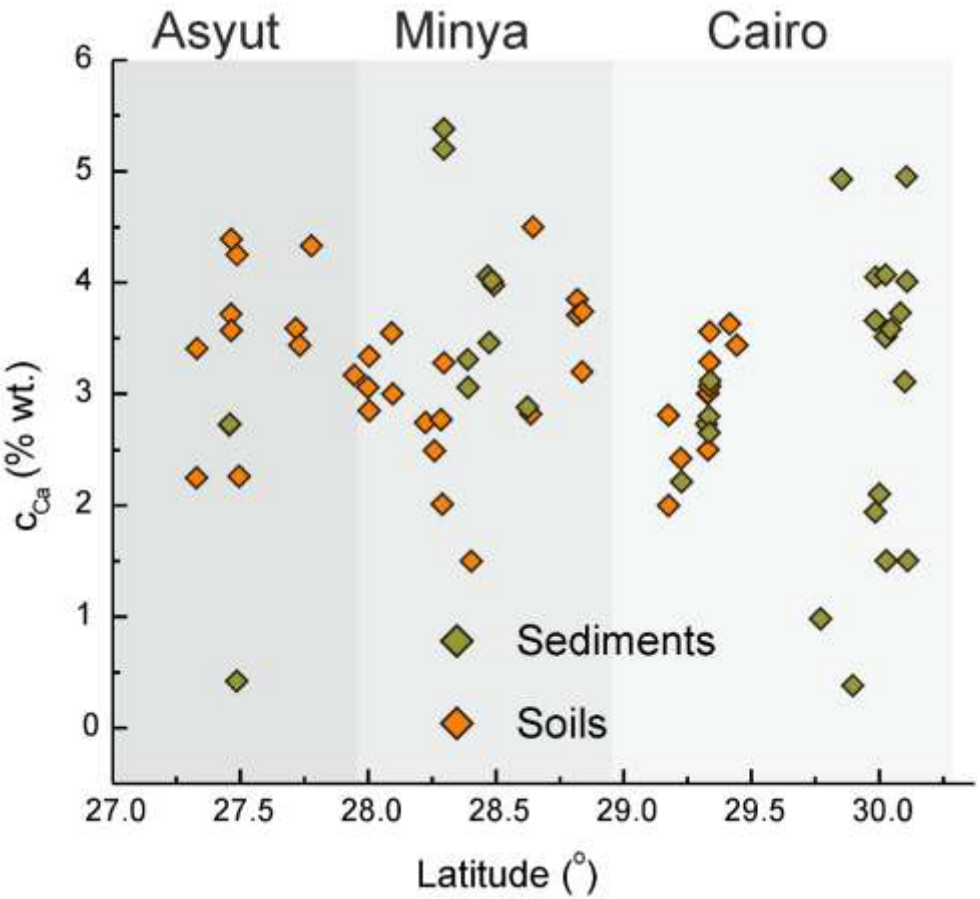
Descriptive statistics

Element	Mean	Median	SD	Min	Max	Congo	Upper Niger	UCC	NASC	WASS	WAS	ANS&S
Na	8982	10550	4384	433	14100	2590	ND	25400	1370	7100	ND	8230
Mg	14650	11450	9548	912	37200	ND	ND	11600	1334	12600	ND	10100
Al	43360	49800	19649	6480	72300	ND	ND	78300	67000	87200	ND	47100
K	8189	8895	3009	1910	12300	9100	ND	15000	ND	16900	ND	ND
Ca	30759	31050	12725	3700	53700	25000	ND	31500	25900	25900	ND	38100
Sc	13	14	6	0	22	16.1	ND	14	30	18.2	11.7	12.7
Ti	10528	9585	7465	271	25600	ND	ND	3300	4196	4400	7038	7370
V	143	168	77	6	268	ND	103	140	130	129	129	130
Cr	173	177	93	8	494	119	153	69	125	130	59.5	103
Mn	915	878	750	44	4490	ND	1403	770	ND	1700	488	739
Fe	42103	43950	20420	2980	72000	78400	ND	41700	14100	58100	ND	37300
Ni	48	52	25	2.6	88	ND	82	55	58	74.5	29	43
Co	22	25	11	1.2	36	23.9	24	17	26	22.5	11.3	18
Zn	74	82	29	4	131	ND	90	67	2.7	208	70	93
As	1.3	1.3	0.5	0.3	2.1	ND	ND	1.6	ND	35.3	6.83	5.3
Br	1.9	1.5	1.8	0.2	8.8	ND	ND	2.1	70	21.5	10	122
Rb	26	27	9	4	40	60	64	110	125	78.5	68	27
Sr	298	331	101	39	396	52	117	350	142	187	175	331
Zr	316	277	280	27	1573	156	82	162	200	160	267	331
Mo	1.4	0.7	1.5	0.2	6.8	ND	ND	1.6	ND	2.98	1.1	ND
Sb	0.3	0.2	0.2	0.0	0.9	ND	ND	0.2	7.3	2.19	0.67	0.18
Ba	468	503	123	79	607	339	595	570	636	522	460	332
Cs	1	1	0	0.1	1	4.4	3.8	3.7	8.5	6.25	5.06	0.81
La	18	19	8	3.0	43	41.7	47	30	31.1	37.4	27	19.9
Ce	36	37	16	4.9	84	94.8	97	58	66.7	73.6	56.7	34.4
Sm	4.1	4.2	2.4	0.4	8.7	6.7	6.9	4.59	5.59	1.29	4.6	3.86
Tb	0.6	0.7	0.3	0.1	1.1	0.72	0.72	0.6	0.5	4.25	0.63	0.6
Yb	1.2	0.9	0.7	0.3	3.1	2.6	1.6	2	1.9	4.04	2.6	1.53
Hf	6.0	3.6	7.0	0.5	38	4	1.7	4	6.3	1.27	6.4	6.86
Ta	0.9	0.9	0.4	0.1	2	1.6	0.8	1.5	0.41	12.1	1.39	0.81
Th	3.5	3.3	2.8	0.9	17	13.8	13.3	11	12.3	12.1	9.2	3.22
U	0.9	0.9	0.6	0.2	3.3	2.4	2.5	2.8	2.7	3.03	3	1.5

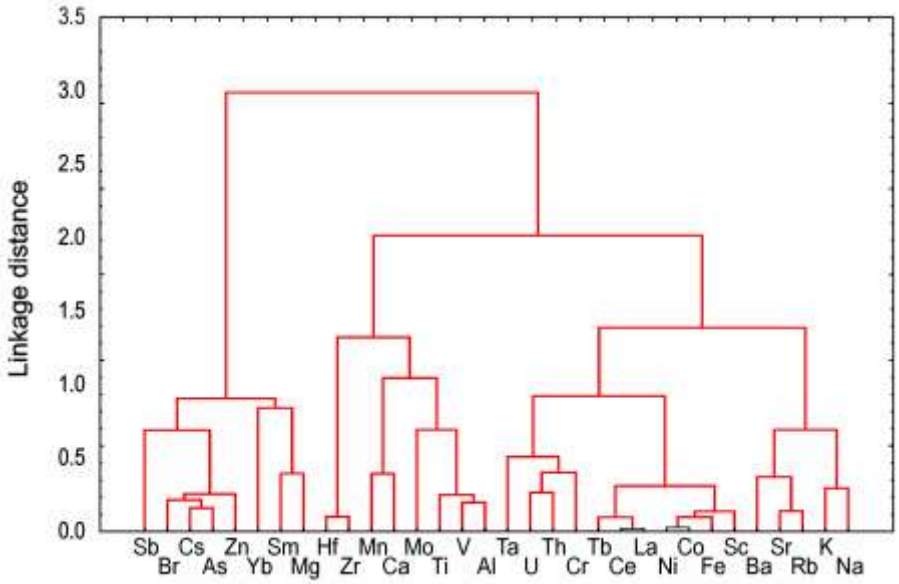
Boxplot


Sediments
Soils
Mean
Median
Mean ± sd
Mean ± 2sd
UCC
14
12
10
8
6
4
2
0
-2
c/c_UCC
Na Mg Al K Ca Sc Ti V Cr Mn Fe Ni Co Zn As Br Rb Sr Zr Mo Sb Ba Cs La Ce Sm Tb Yb Hf Ta Th U
Element

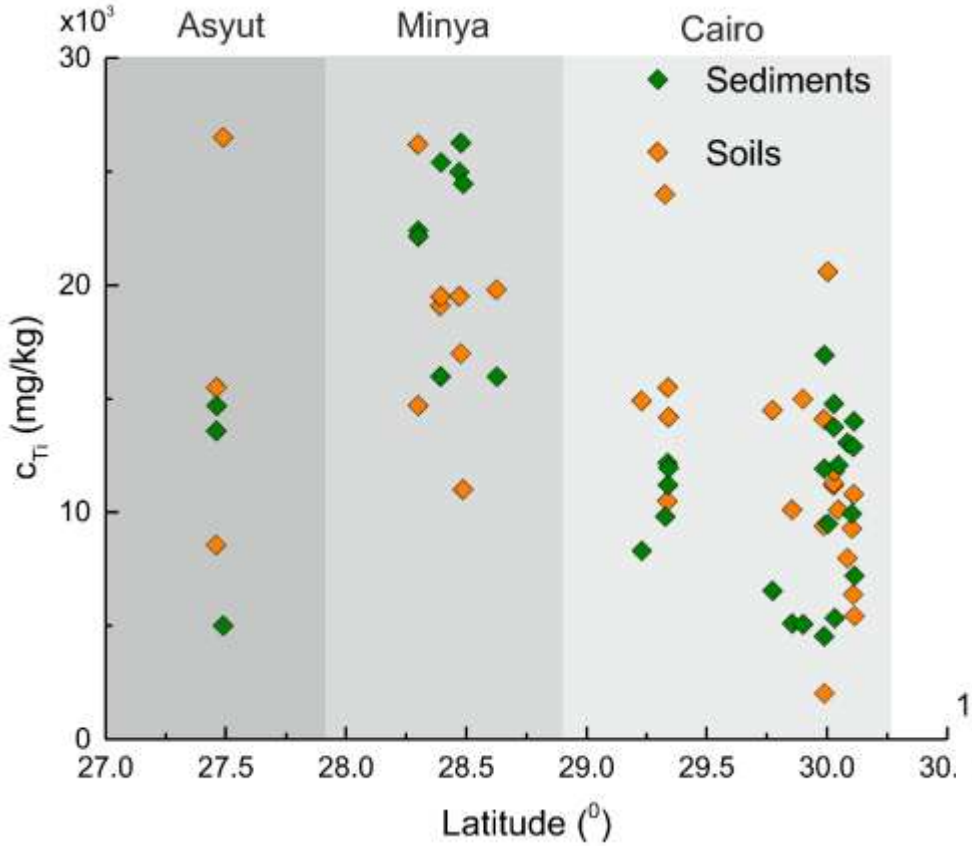
Distribution of Ca with Lat. (^{0})



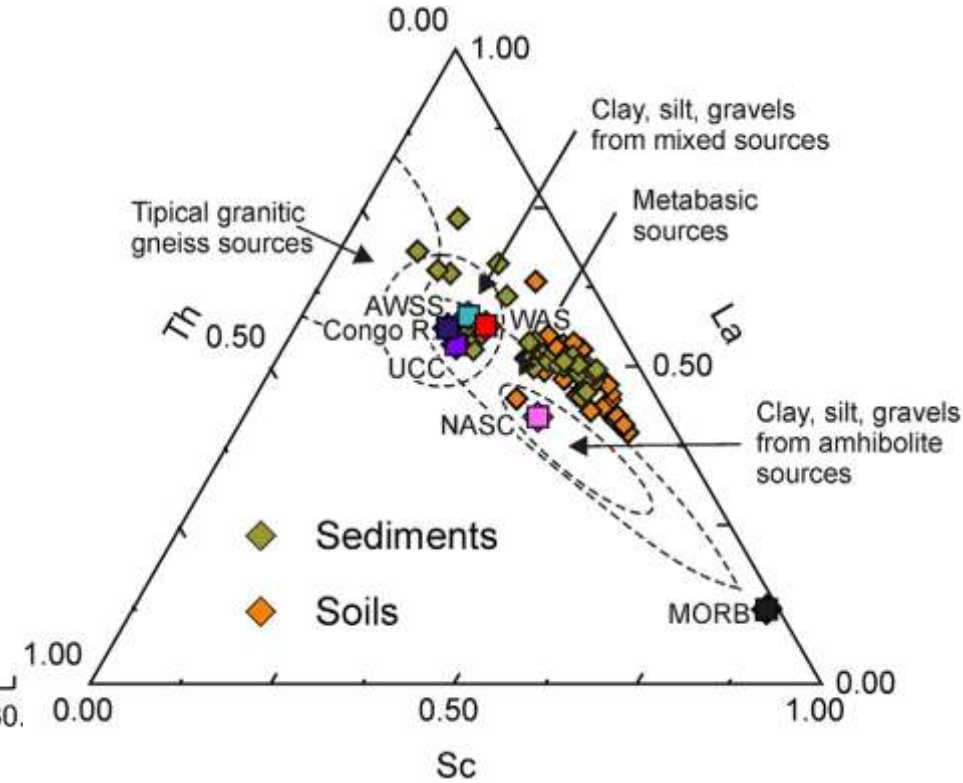
Tree diagram of all 32 elements



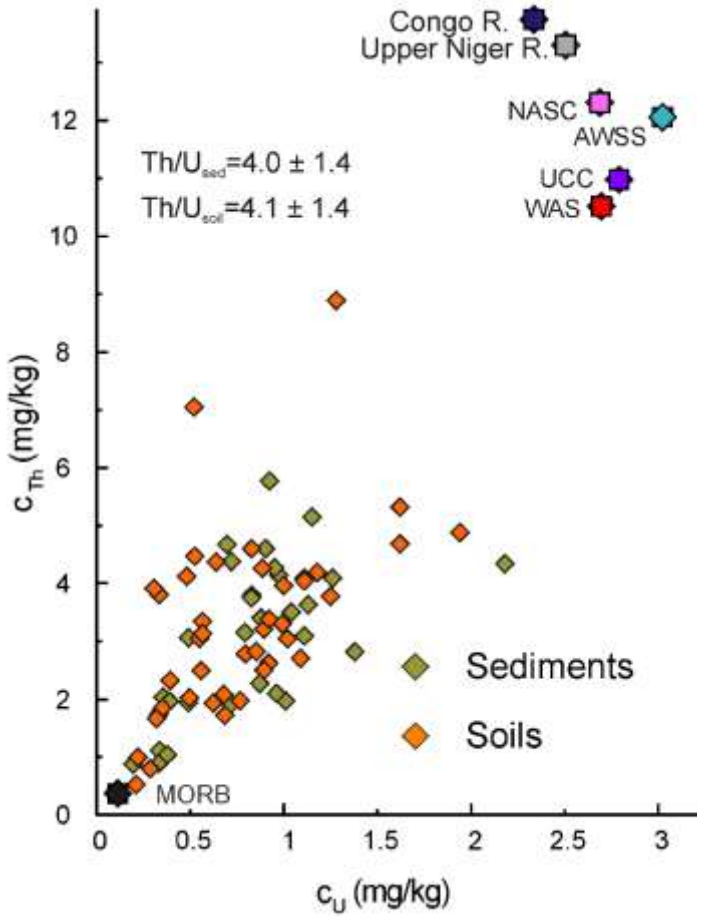
Distribution of Ti with Lat. (^{0})



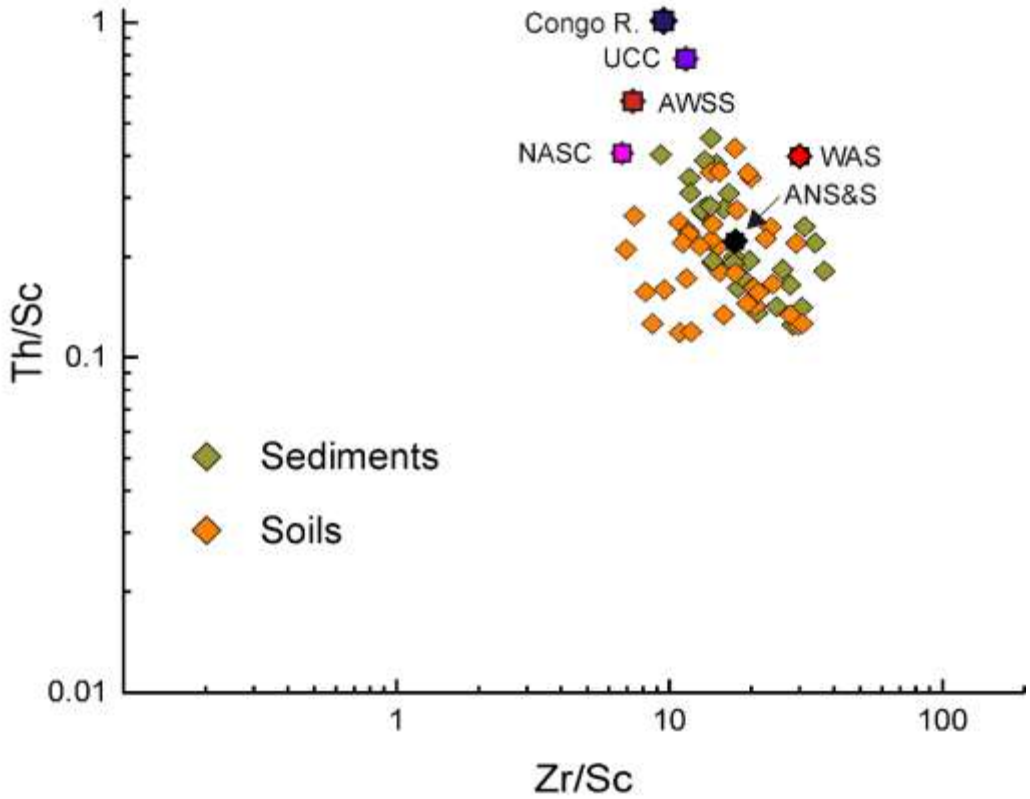
Ternary diagram



Correlation between U and Th



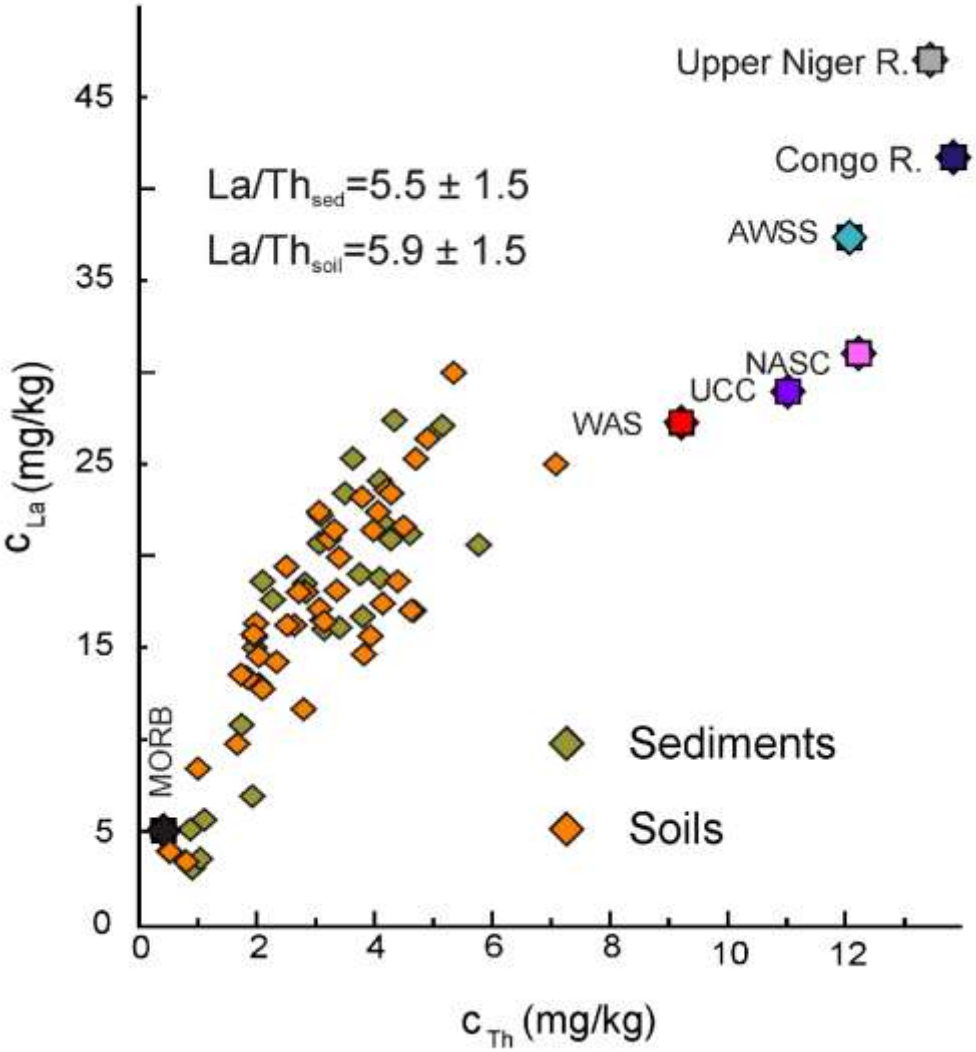
Th/Sc vs Zr/Sc



Correlation between La and Th

A possible presence of certain materials of natural volcanic origin in soil an sediments can be obtained
by analyzing the reciprocal distribution of low mobility and incompatible elements Sc, V, Cr, Ni, Zr, La, Hf, and Th.

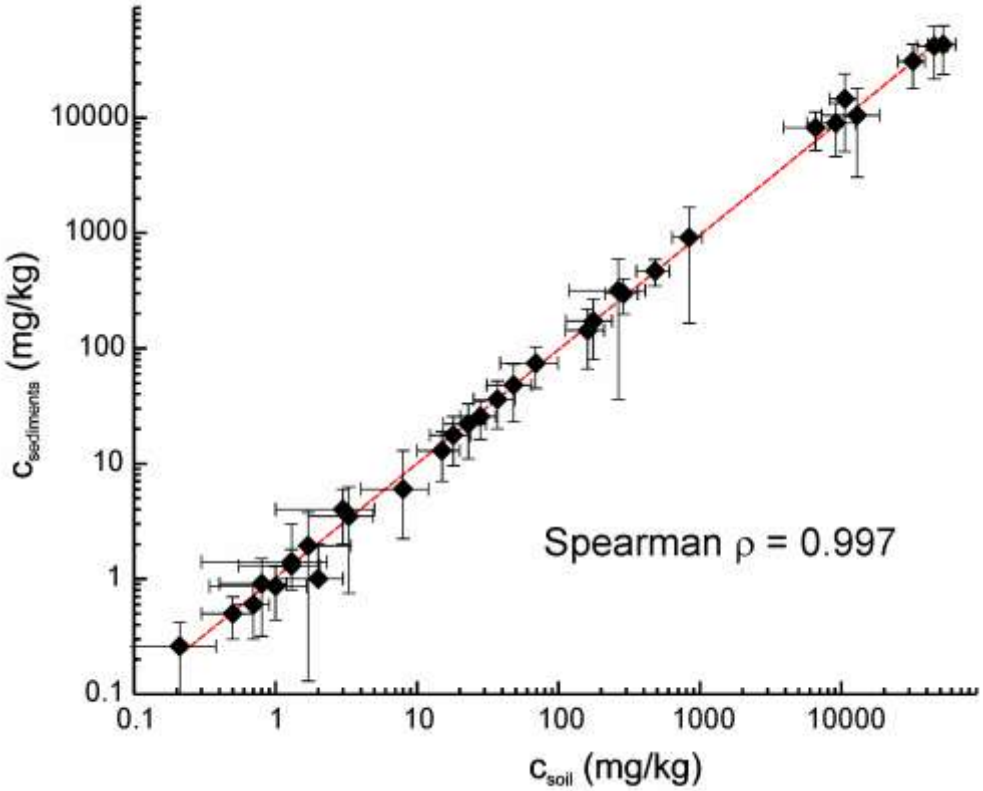
Both investigated soil and sediments contain a certain amount faction of mafic detritus, which provenance could be attributed, as mentioned, to the High Ethiopian Plateaus mainly consisting
of basal with a small amount of felsic volcanic rocks



Correlation between soil and sediments content

A linear correlation between soil and sediments better described by a Spearman's correlation coefficient equal to
0.977 at $p < 0.01$.

It is proven that there is a relative similitude between the sediment and soil.



Normality test

it is obviously from the obtained data that in all elements there is no coincidence between average values and medians. Moreover, neither skewness nor kurtosis point towards normal distribution, as both parameters are far away from 0 to 3 respectively; values characteristic for a Gaussian distribution.

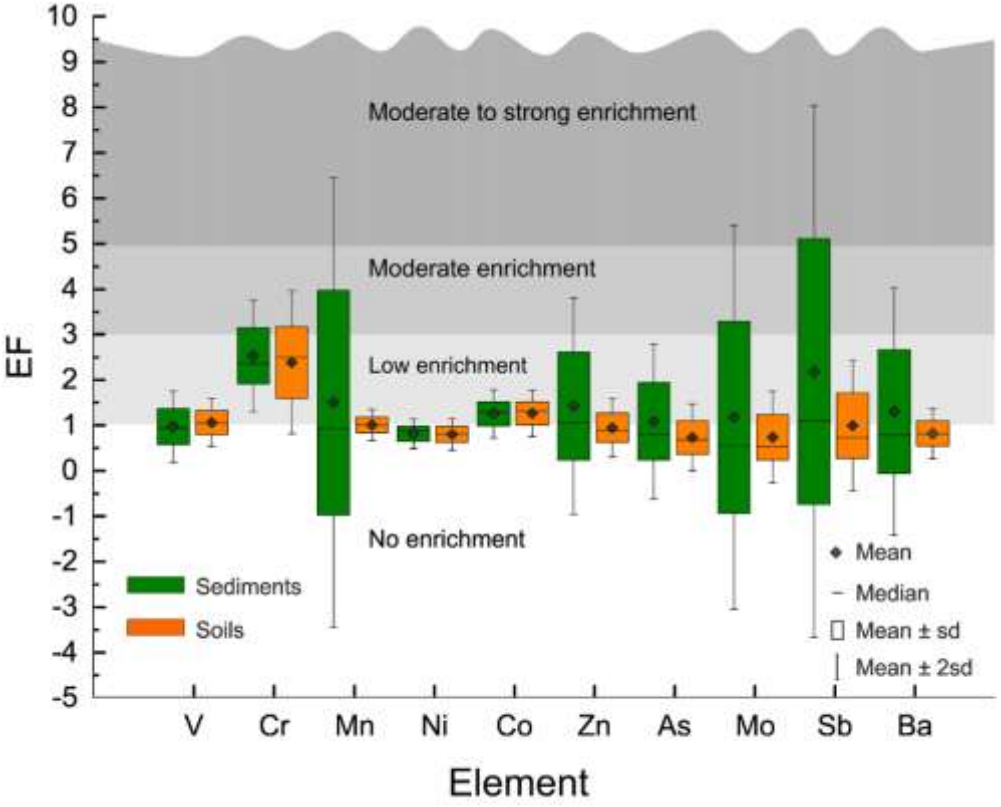
A possible explanation of this peculiarity consists of a reduced number of samples, as well as of the fact that either major or trace element distribution is neither normal nor lognormal.

Shapiro-Wilk test was used to check this hypothesis. With the exception of Ca in both soils and sediments for which the Shapiro-Wilk test confirmed a possible normal distribution with a probability of 50% and 88% respectively ($p < 0.5$ and 0.88), no other element presented in both media confirmed the normal distribution.

Pollutant impact

Overall, and as a common notice, the content of pollutants is higher in sediment than in soil samples. Sediments are characterized by higher metal contents due, in part, to the high specific surface of the smaller particles. This enrichment is mainly due to surface adsorption and ionic attraction.

the presence of numerous factories and enterprises that are using Cr such as iron and stainless steel factories and paints industries, mainly in the Helwan Area. However, there is no a noticeable contamination by metals, except a moderate contamination (0 < Igeo < 1) with Cr 0.41 and 0.36 for sediment and soil samples, respectively. This might be due to the uncontrolled waste discharge in the Nile River from these enterprises.



Concluding remarks

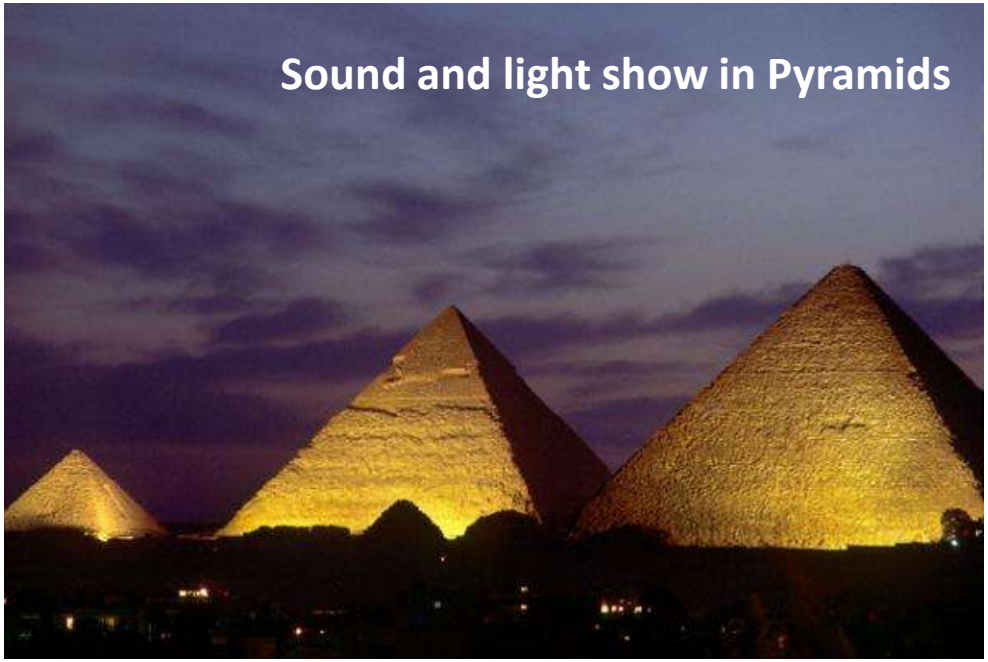
- The content of 32 major and trace elements in 72 samples of sediments and soils collected along the Nile valley from Asyut to Cairo was determined using ENAA.
- The experimental data were compared with corresponding data from the Congo and Upper Niger Rivers, Upper Continental Crust, North American Shale Composite, Average Soil and Average Sediment as well as with existing data regarding other sections of the Nile valley.
- The distribution of both major rock forming and trace elements confirms the presence, besides of detrital material close to the Upper Continental Crust, of a certain amount of igneous material, most probably resulting from weathering of the Ethiopian Highlands and transported by the Blue Nile.
- Accordingly, was better evidenced by the average content of the Light Rare Earth Elements La and Ce, as well as of Th and U, which are significantly lower than the Continental material as well as the suspended sediments of the great African Rivers Congo and Upper Niger.

- At the same time, the distributions of possible pollutants such as Ni, Zn, and As suggest that the investigated sector of the Nile valley is not seriously contaminated with heavy elements, so that, in spite of a human activity that lasted four millennia, the Nile River continues to be less affected by any anthropogenic activity.

Prospective

- On the question of the ecological situation assessment using different biotic and abiotic components of the marine ecosystems of the Egyptian Red Sea coast.
  - Marine sediments,
  - coral reefs,
  - mangrove,
  - algae,
  - Molluscs…etc.

THANKS FOR YOUR PAYING ATTENTION



An expert is a person who has made all the mistakes that can be made in a very narrow field."
— Niels Bohr