Distribution Pattern of NORM on Red Sea Shore Sediment in Relation to NON-Nuclear Industries

Dr. Ashraf E. Khater

King Saud University, Saudi Arabia

Nuclear and Radiological Regulatory authority, Cairo-Egypt

http://faculty.ksu.edu.sa/Khater/default.aspx

Introduction

The Red Sea is a deep semi-enclosed and narrow basin connected to the Indian Ocean by a narrow sill in the south and to the Suez Canal in the north.

- The Red Sea is one of the most saline bodies of water in the world, due to high evaporation. Salinity ranges from between ~36 ‰ in the southern part due to the effect of the Gulf of Aden water and reaches 41 ‰ in the northern part, due mainly to the Gulf of Suez water and the high evaporation.

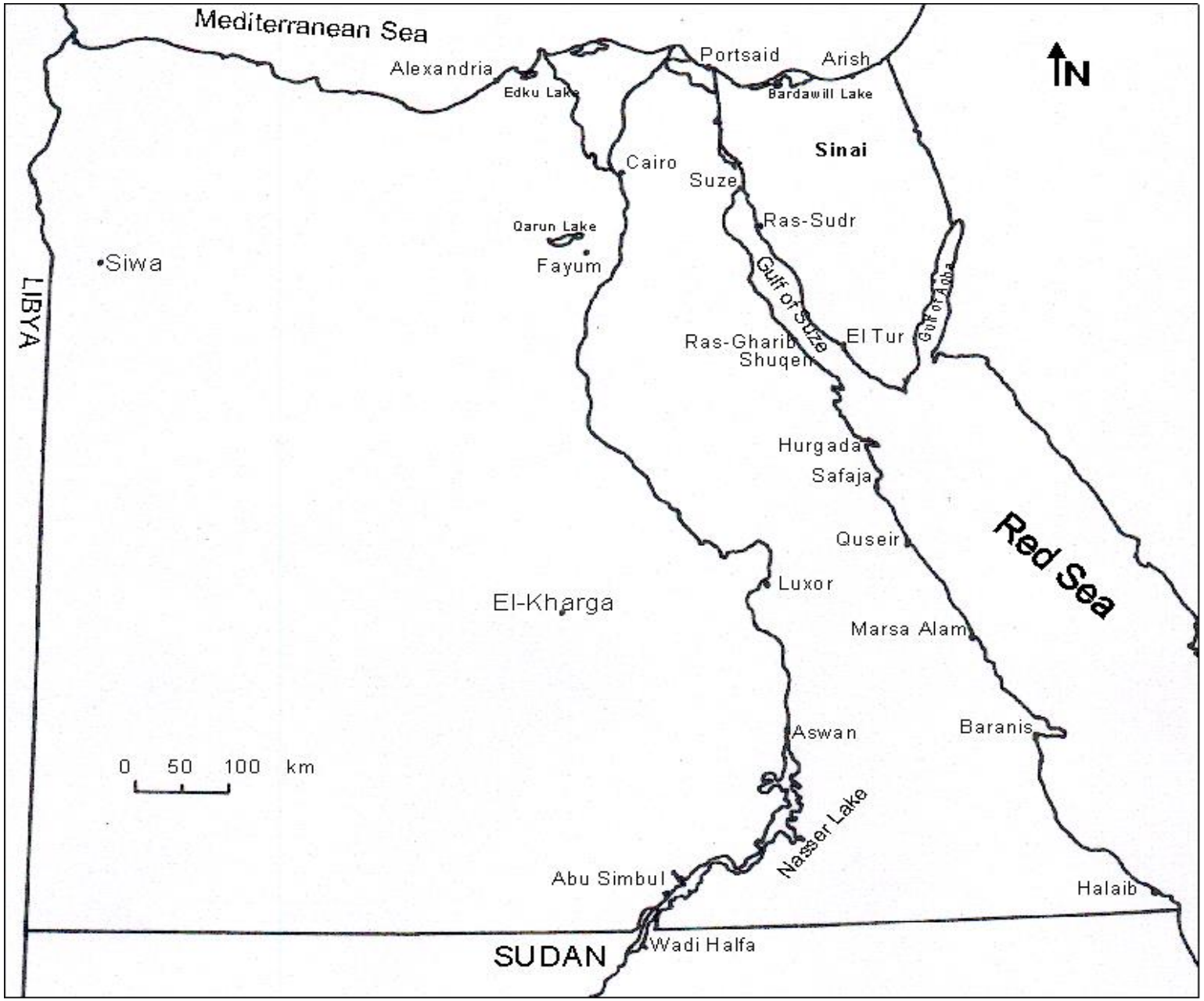
- Egypt has about 700 km of coastline along the Red Sea proper, which is of great environmental, economical and recreational value.



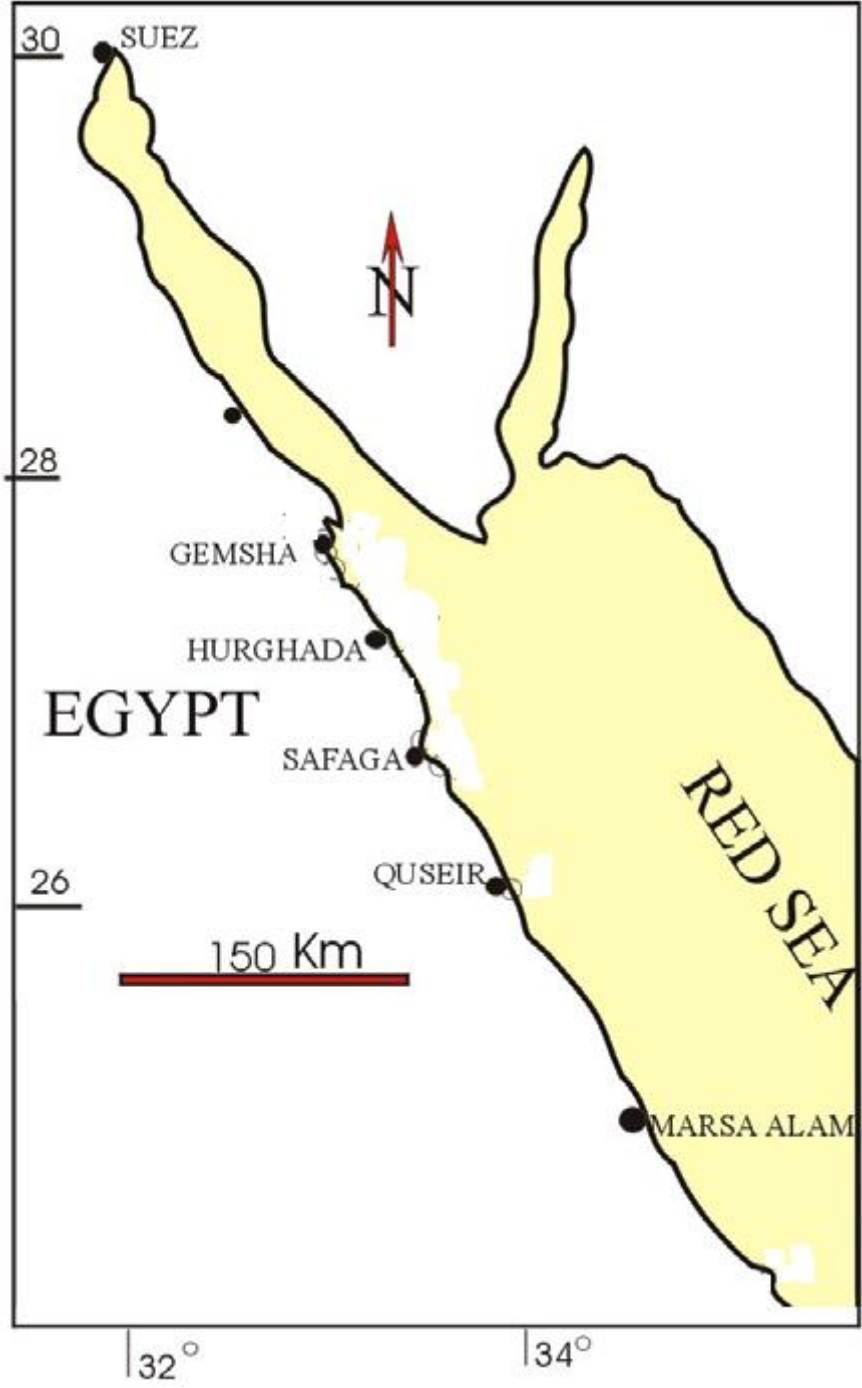
- Since the beginning of the 70's, the entire region has suffered from important industrial, touristic and demographic mutations, which are expected to affect the Red Sea environment, particularly the coastal area.

- Unless adequate and severe measures are implemented to protect it, coral reefs, mangrove stands and sea grass beds, ecosystems specific to tropical seas and characterized by their biological diversity will be subjected to dramatic and probably irreversible damage.




Mediterranean Sea
Alexandria
Edku Lake
Portsaid
Arish
Bardawill Lake
N
Sinai
Cairo
Suze
Ras-Sudr
Qarun Lake
Siwa
Fayum
LIBYA
Gulf of Suze
Gulf of Aqba
El Tur
Ras-Gharib
Shuqeir
Hurgada
Safaja
Red Sea
Quseir
Luxor
El-Kharga
Marsa Alam
Aswan
Baranis
0 50 100 km
Nasser Lake
Abu Simbul
Halaib
Wadi Halfa
SUDAN


MEDITERRANEAN SEA
(Egipciacvm Mare)
CAIRO
SINAI
ASSIUT
QENA
RED SEA
Study area
MARSA ALAM
EGYPT
ASWAN
150 Km
30°
32°
34°
36°
30°
28°
26°
24°


30
SUEZ
N
28
GEMSHA
HURGHADA
EGYPT
SAFAGA
RED SEA
26
QUSEIR
150 Km
MARSA ALAM
32°
34°

EGOLOGICAL STRESSES

OIL PRODUCTION INDUSTRIES:

In the Gulf of Suez, the northern part of the Red Sea, there are about 90 % of the Egyptian oil exploration and production activities, which could be a significant source of environmental contamination with technological enhanced naturally occurring radioactive materials (TENORM).

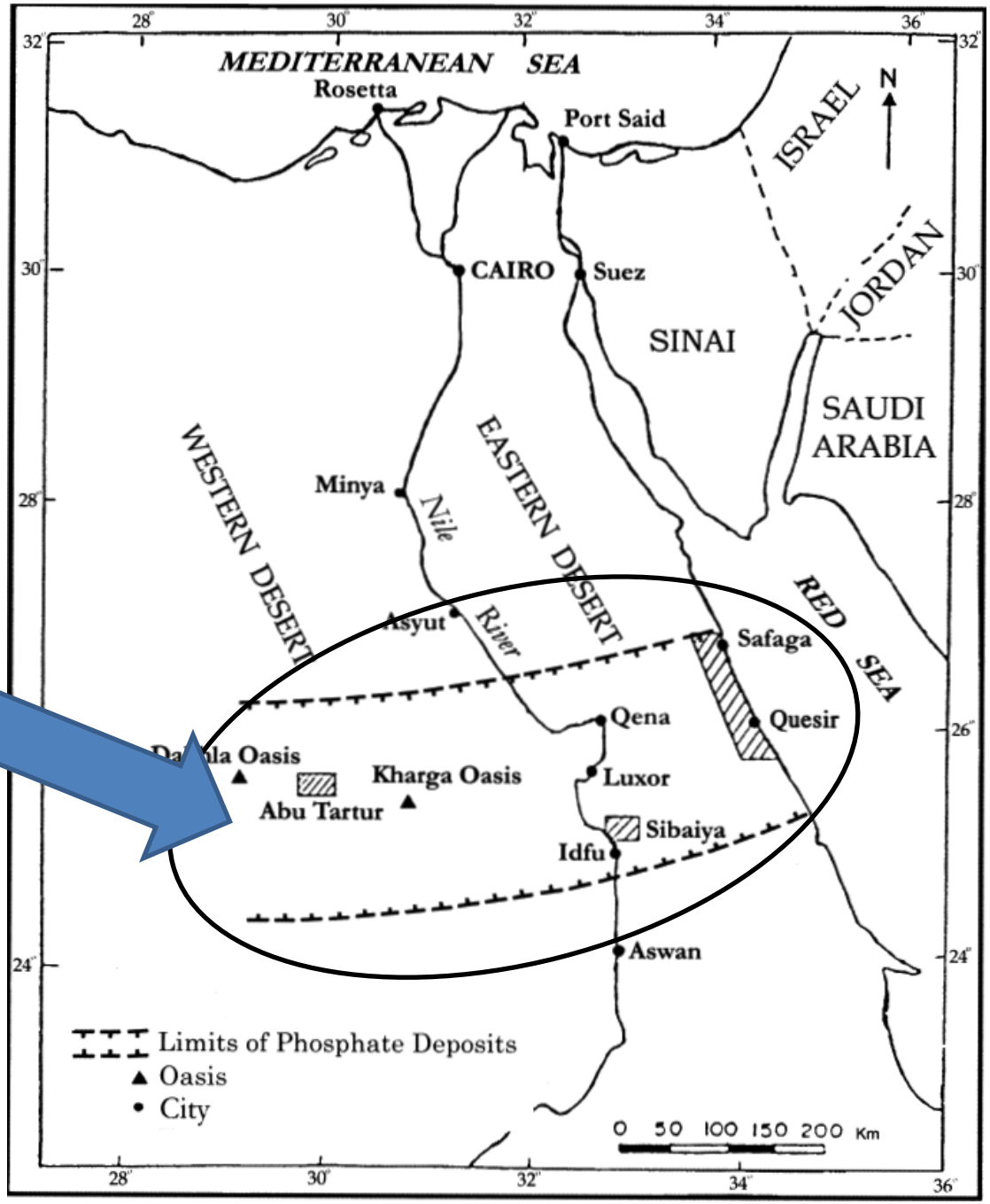
PHOSPHATE ORE MINING AND SHIPPING:

Two main centers for phosphate ore mining; Safaga and Quseir, and

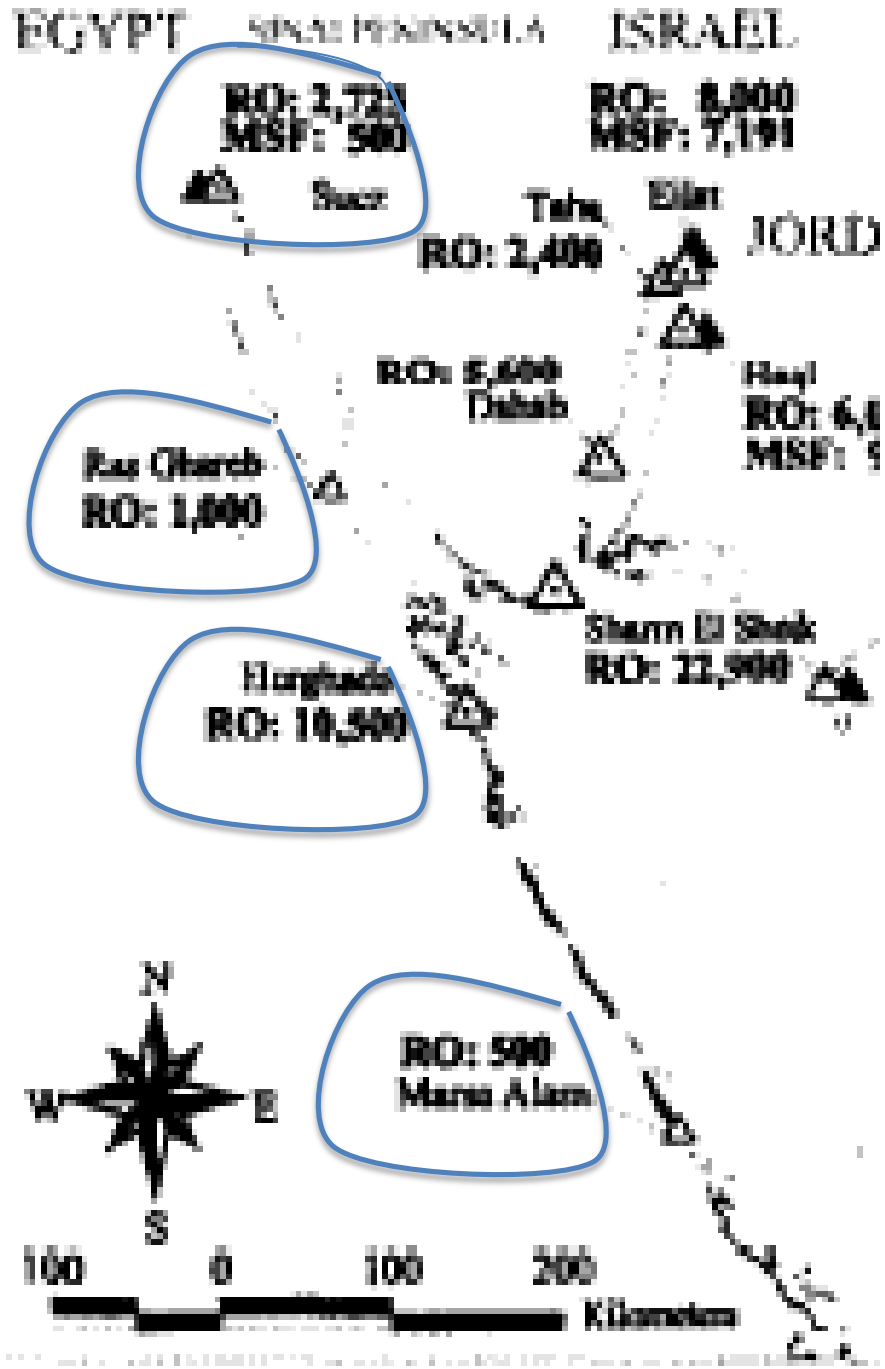
Three shipping harbors. Phosphate ore dust spilled over into the Sea during shipping is considered as a continuous source for contaminating the Red Sea coastal environment.

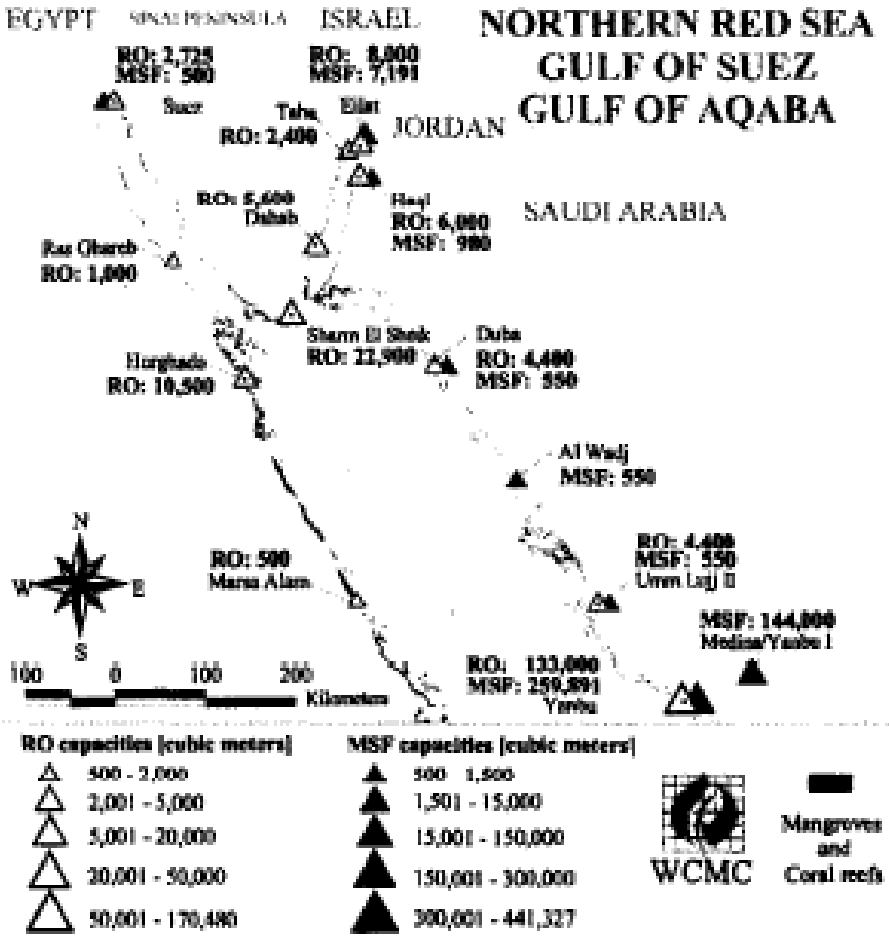
DAWU Phosphate formation

Three main phosphate mining locations



WATER DESALINATION





EGOLOGICAL STRESSORS

- Phosphate mining
- Industrial waste water and sewage
- Oil industry
- recreation
- shipping
- Housing

shipment operations of El-Hamrawein

drainage of reject water of desalination water plant

AIMS OF THE WORK

- To assess the spatial distribution pattern and levels of the NORM in the Egyptian Red Sea Coastal environment.
- To build up a scientific bases to evaluate the present radio-ecological impacts of the non-nuclear industries (e.g. oil production and phosphate mining) on the coastal environment.

Also, these data will be available for subsequent evaluations of the possible future environmental contamination due to the non-nuclear industries.

To help policy makers to indentify the anthropogenic impacts and better assess the needs for remediation .

SAFE AND PROTTECT THE ENVIRONMENT

Experimental work

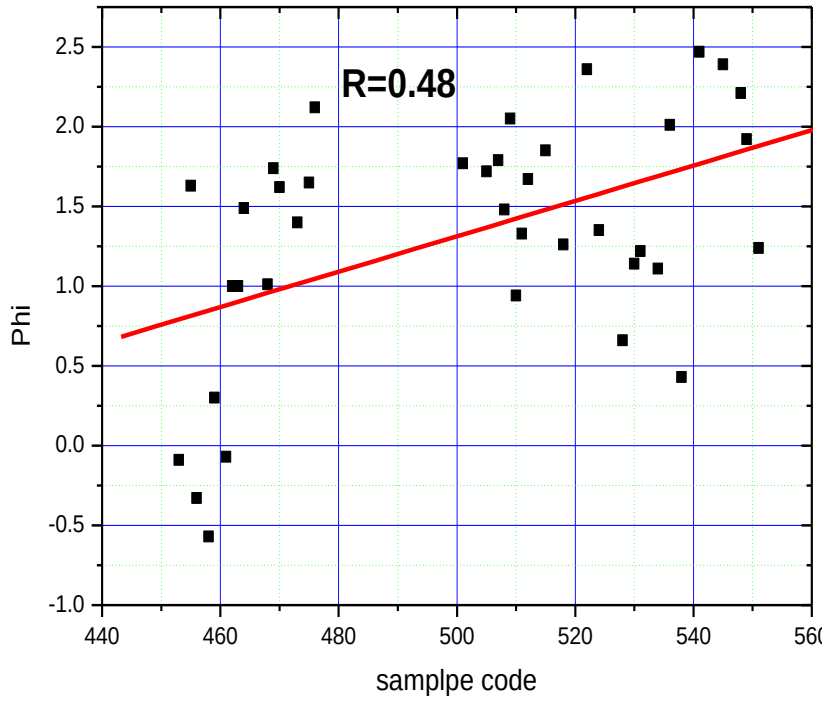
- **39 shore sediment samples,**
- **Mean grain size; total Ba, Sr and HCO_3; NORM (Ra-226, Ra-228 and K-40; Total U, Th, K; Leachable U, Th, K)**
- **Analytical techniques; AA, gamma spec, ICP-MS**




RESULTS and DISCUSSION

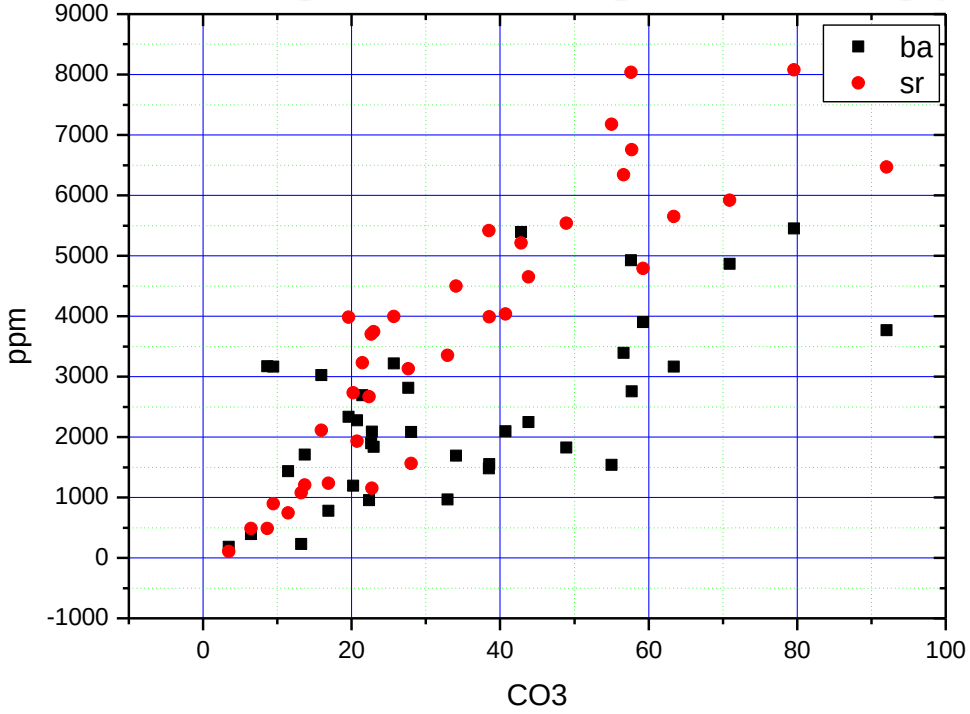
❖MEAN GRAIN SIZE, Ba, Sr AND CO_3

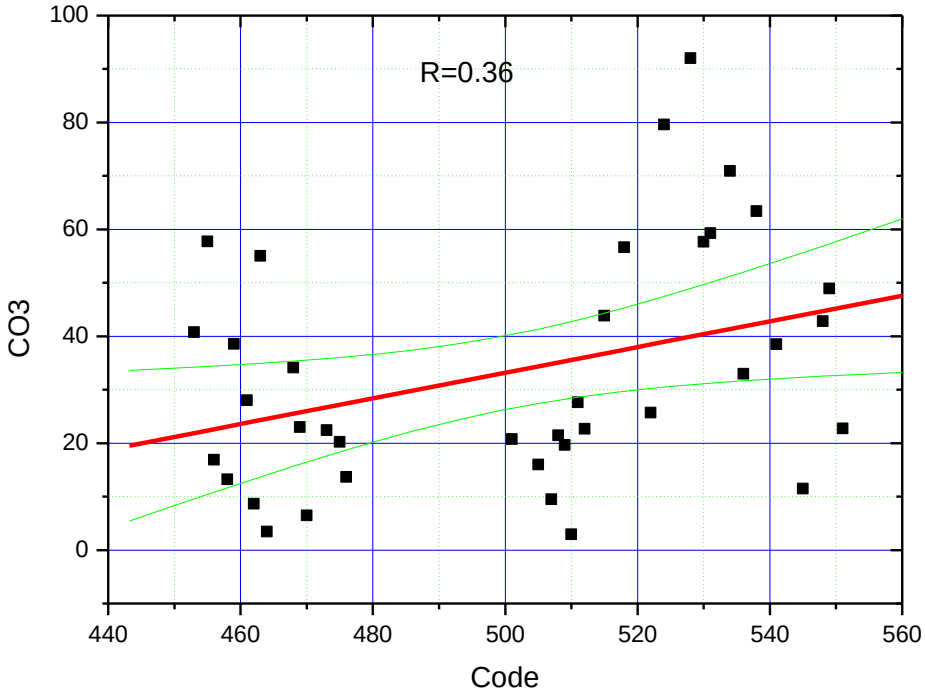
➢The beach sediments in the study area are predominantly sands. The grain size of the sediments increases from south (Marsa Alam) to north (Shuqeir)

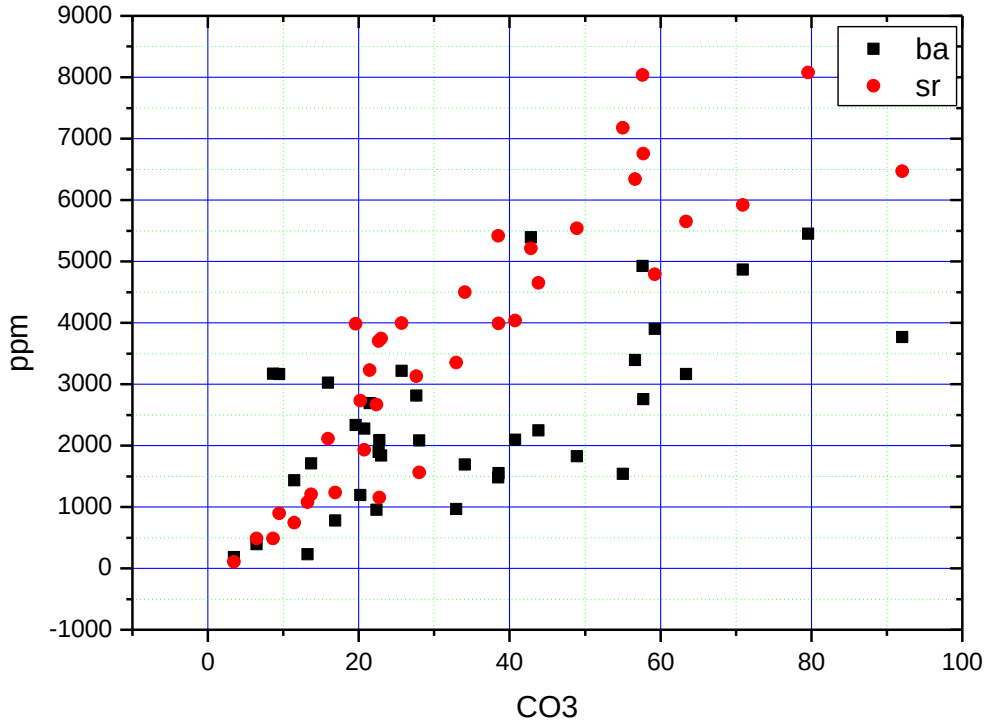


The content of terrestrial deposits is the major control in determining the mean grain size of sediment where most of the coarse sands are mainly quartz, feldspars, and other silicate mineral grains.

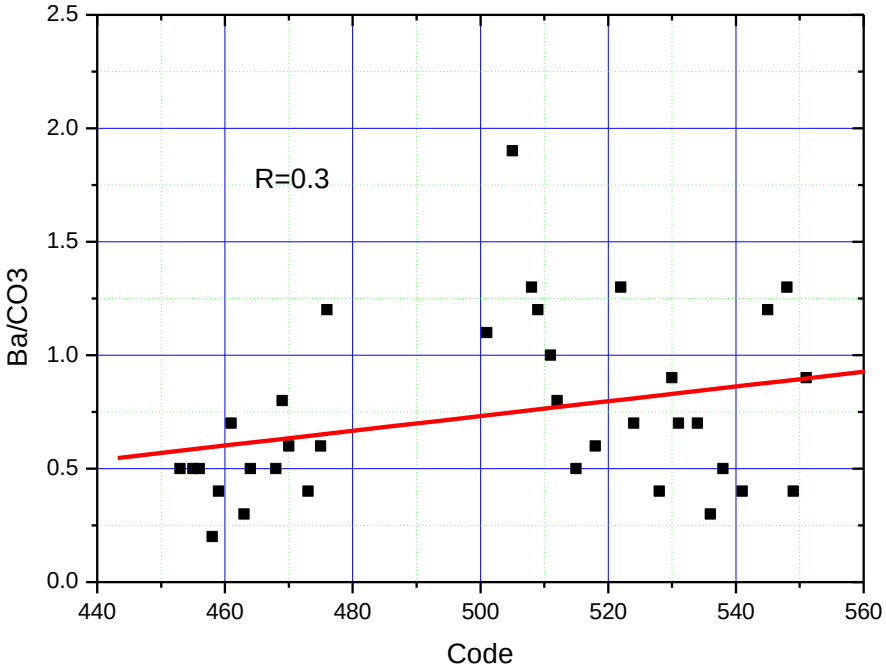
However, the low contribution of terrestrial deposits to the shore in the south led to the fineness of beach sediments. This is because eroded carbonate grains are easier to be broken than silicate grains during reworking processes.

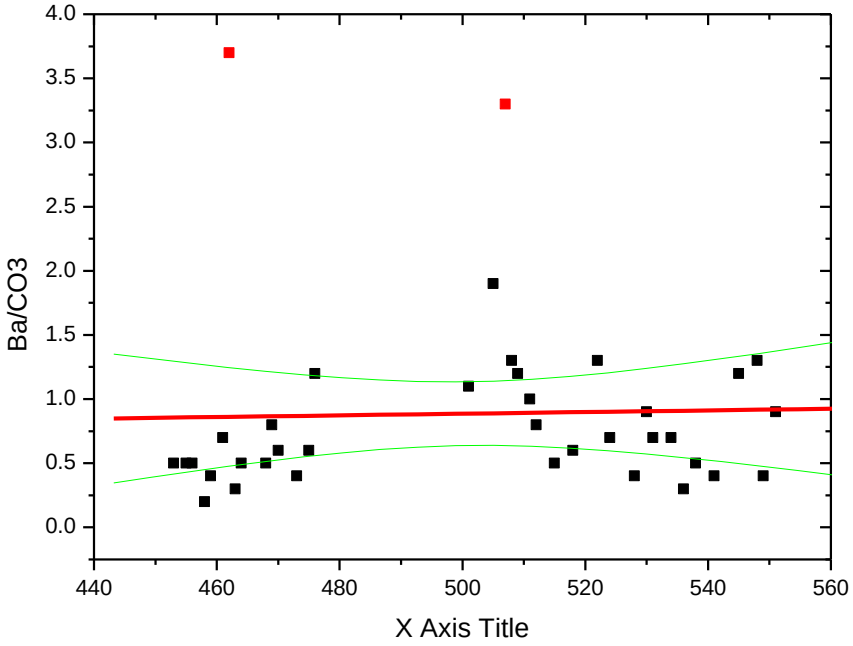






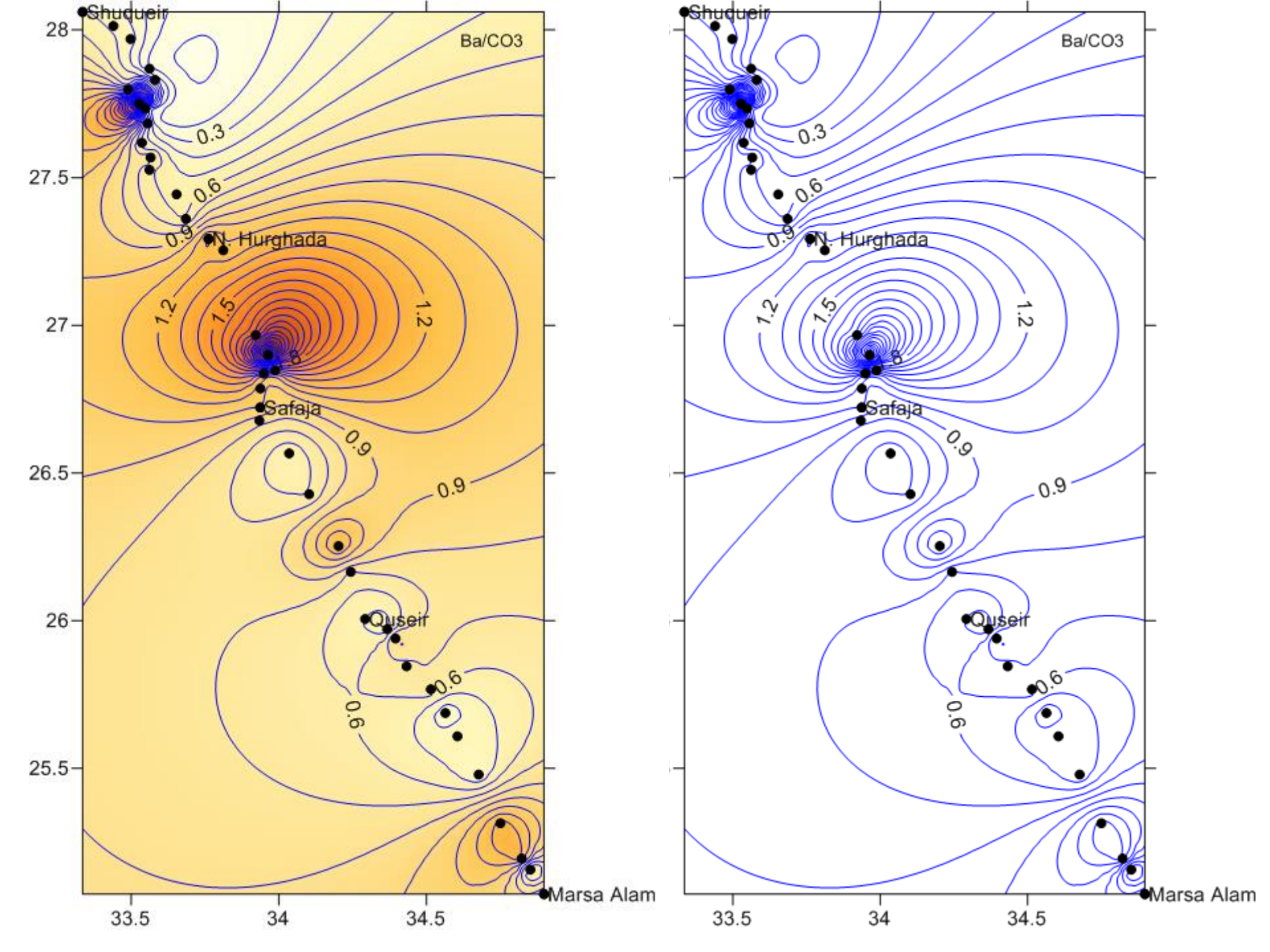
Barium and strontium correlate well with total carbonate content (Fig….), as the two elements decrease from south to north following the same spatial distribution of carbonate. The association of barium and strontium are noticed by many authors





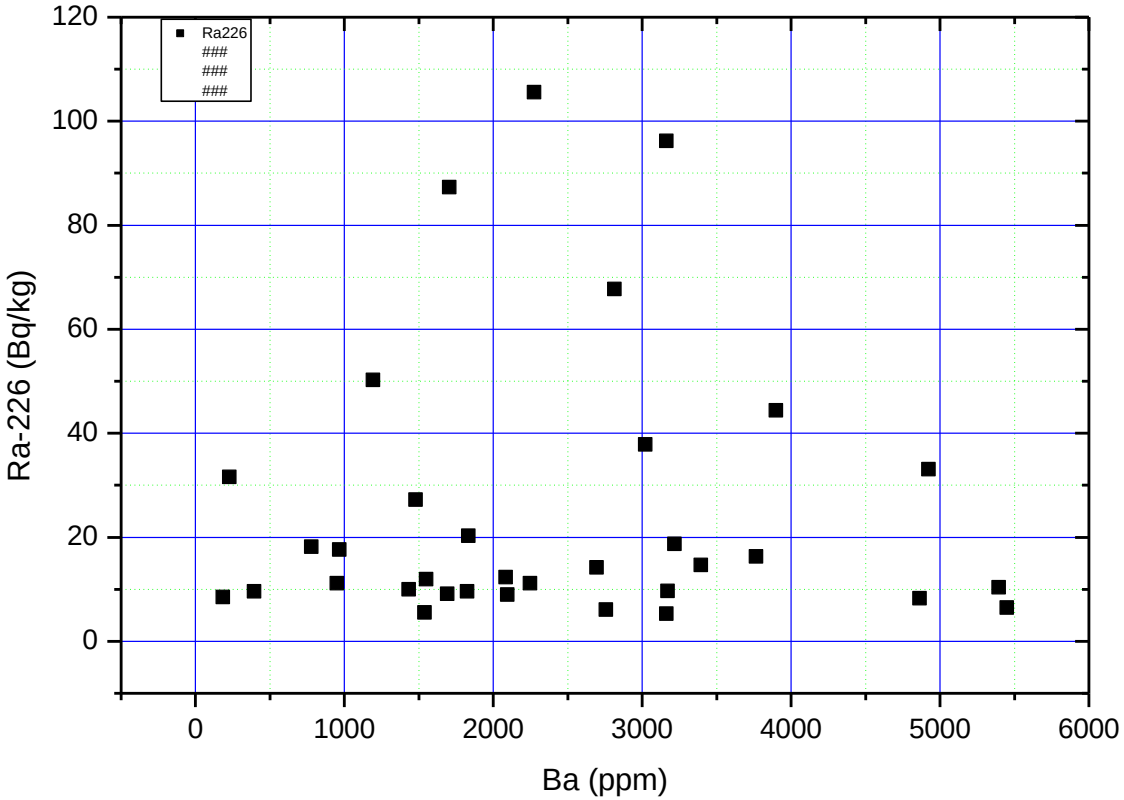
Non-carbonate barium increases from south (Marsa Alam) to north (Shuqeir), where oil exploration and production processes are operated. ------ barium-bearing mud used during drilling operations of oil wells



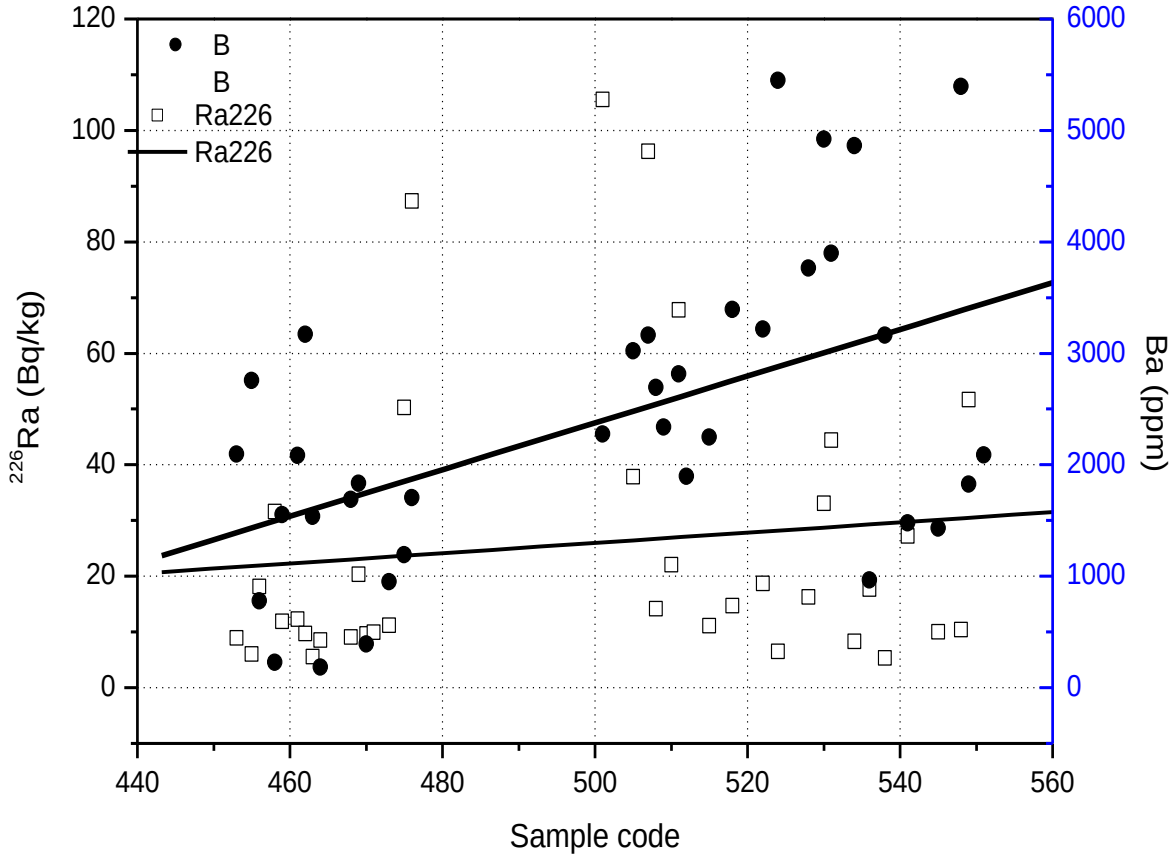


Ba/CO3
Shudueir
N. Hurghada
Safaja
Quseir
Marsa Alam
0.3
0.6
0.9
1.2
1.5
1.8
28
27.5
27
26.5
26
25.5
33.5
34
34.5
Ba/CO3
Shudueir
N. Hurghada
Safaja
Quseir
Marsa Alam
0.3
0.6
0.9
1.2
1.5
1.8
33.5
34
34.5

NORM:

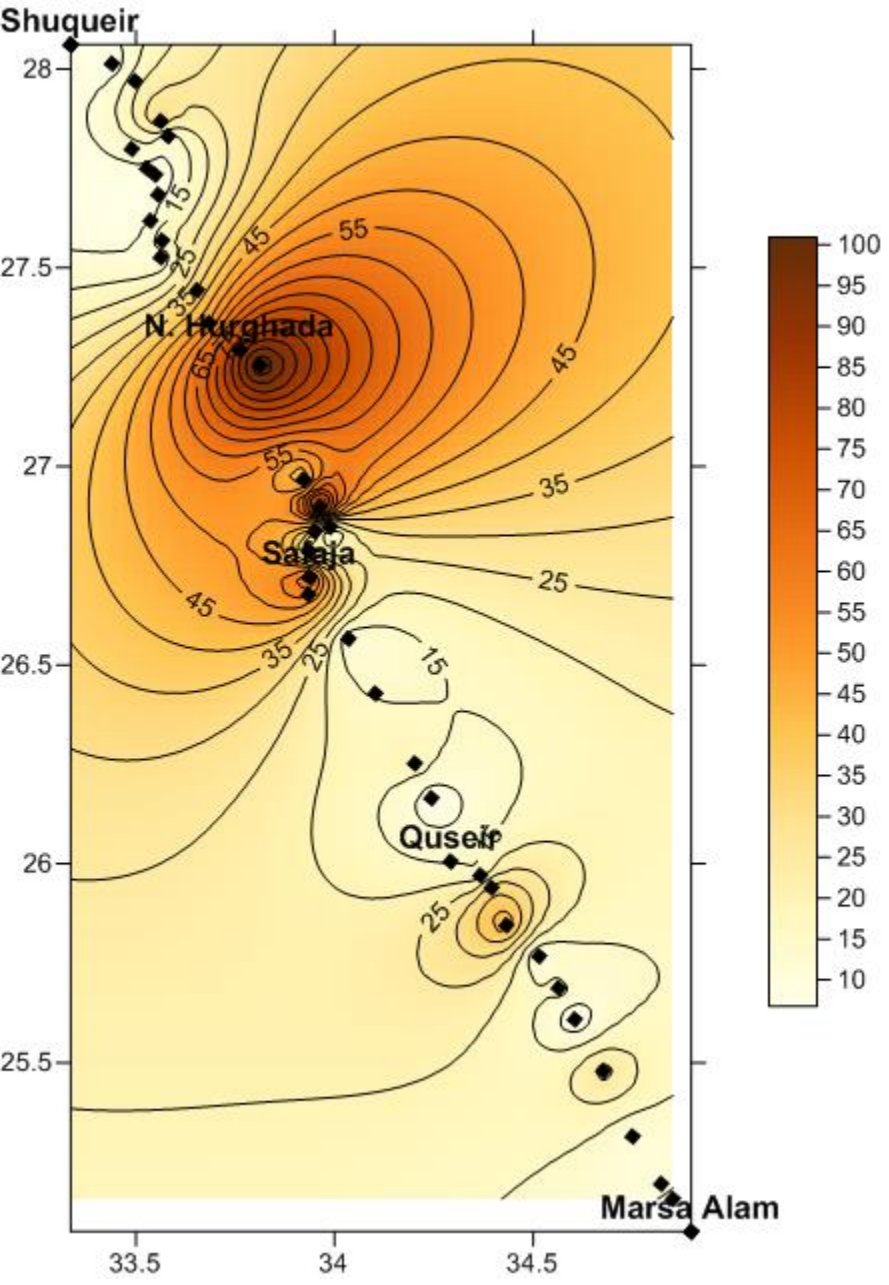
❖The relationships between ^{226}Ra and Ba were weak with correlation coefficient (R) values of **0.01.**

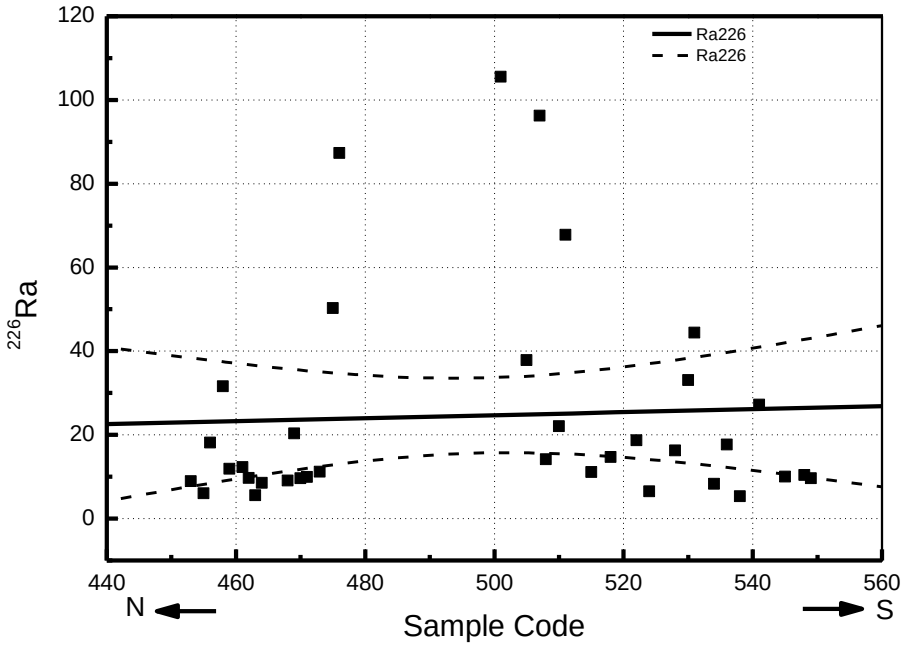


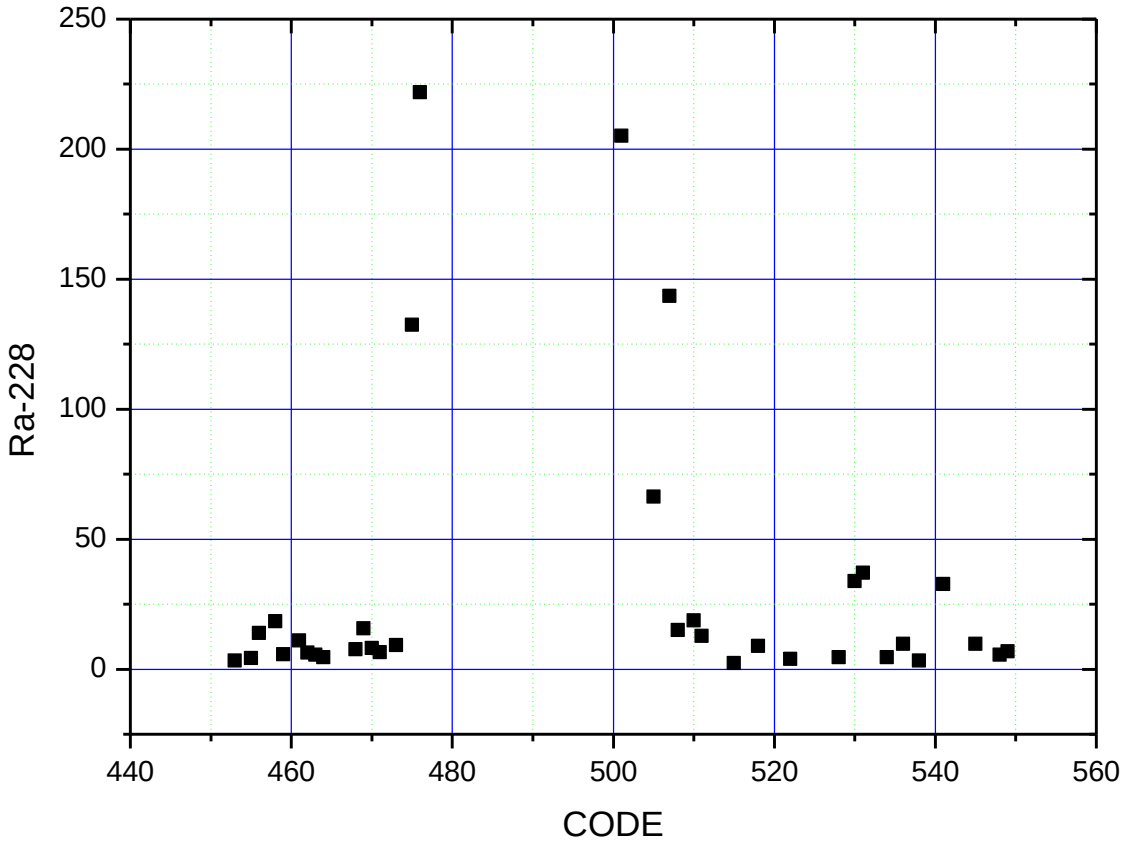
The weak correlation between radium and barium could be due to the possible anthropogenic inputs of barium and radium-226 as a result of oil exploration activities and phosphate mining-shipment activities, respectively.


B
B
Ra226
Ra226
^{226}Ra (Bq/kg)
Ba (ppm)
Sample code
120
100
80
60
40
20
0
6000
5000
4000
3000
2000
1000
0
440
460
480
500
520
540
560

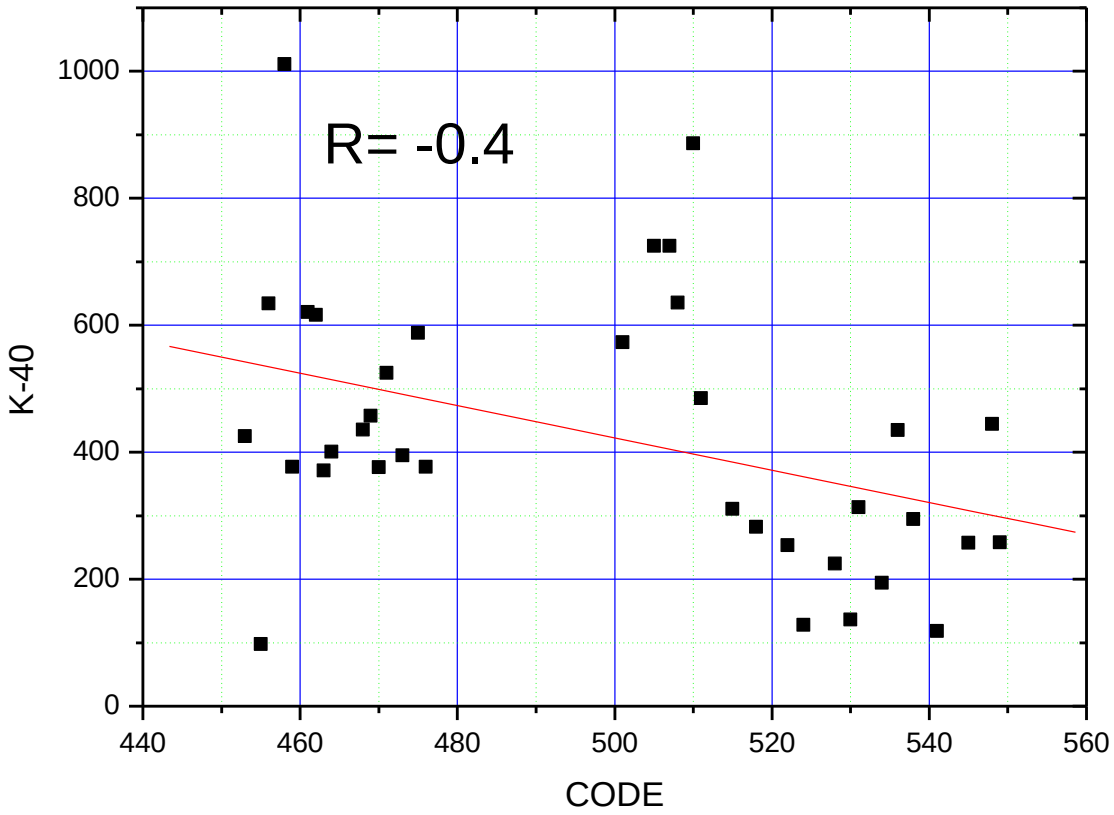




Shuqueir
N. Hurghada
Safaja
Quseir
Marsa Alam
28
27.5
27
26.5
26
25.5
33.5
34
34.5
15
25
35
45
55
65
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10

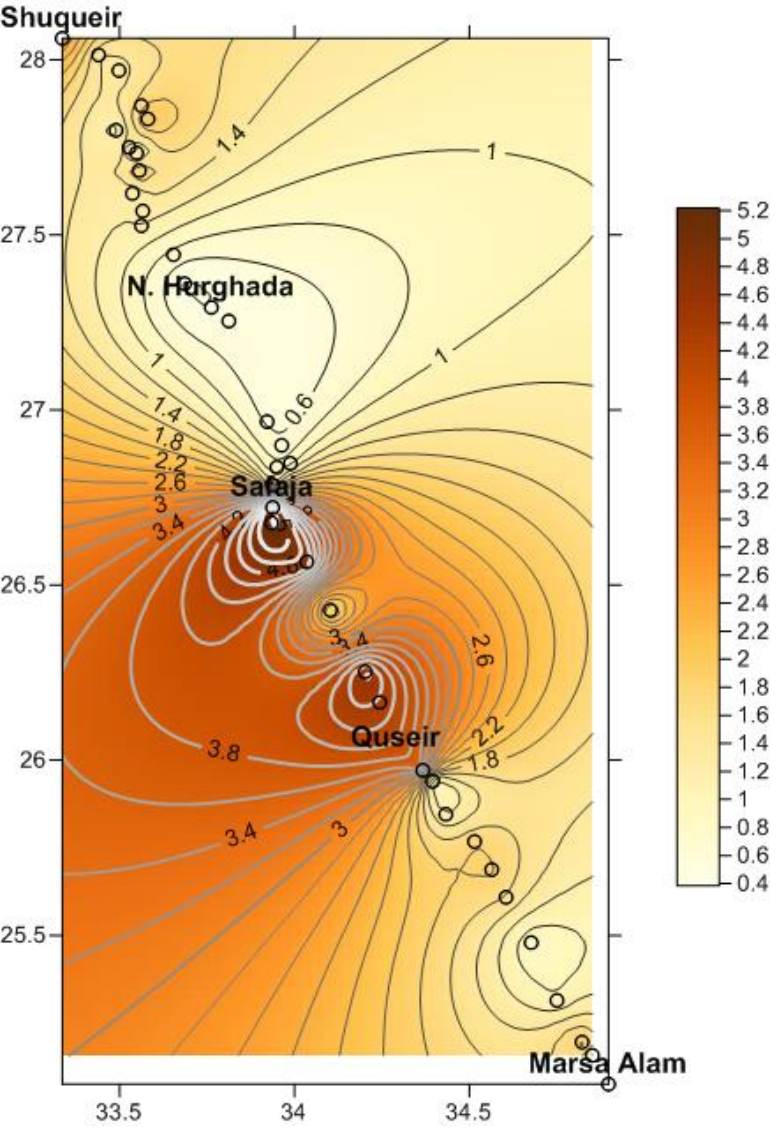

Ra226
Ra226
^{226}Ra
120
100
80
60
40
20
0
440
460
480
500
520
540
560
N
S
Sample Code

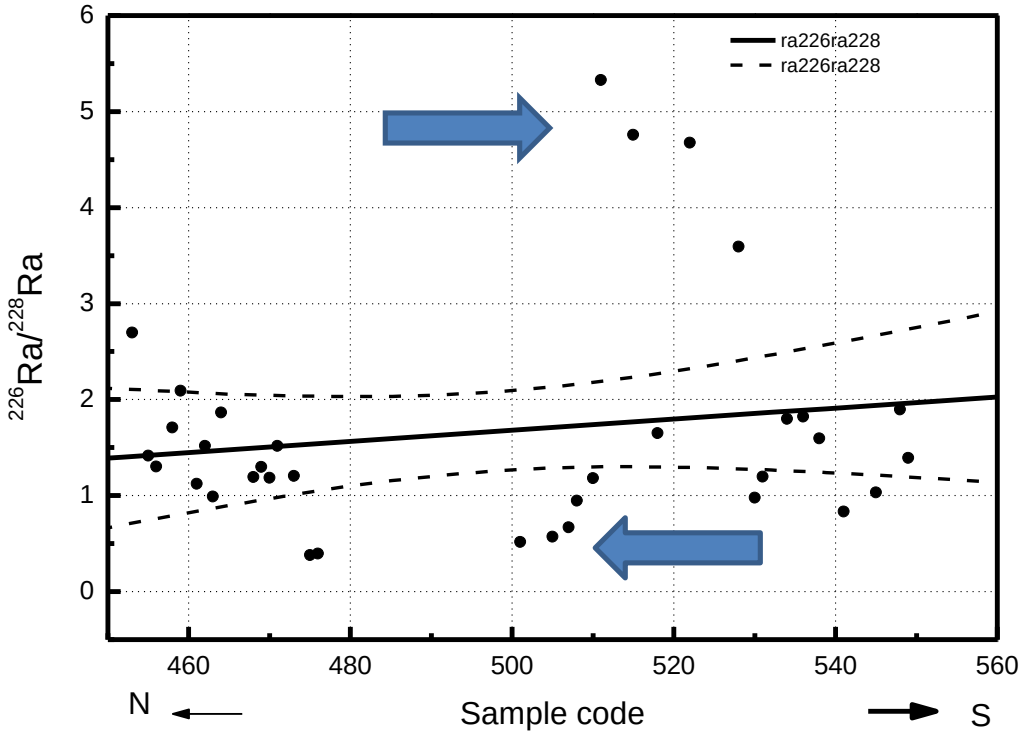

250
200
150
100
50
0
Ra-228
440
460
480
500
520
540
560
CODE

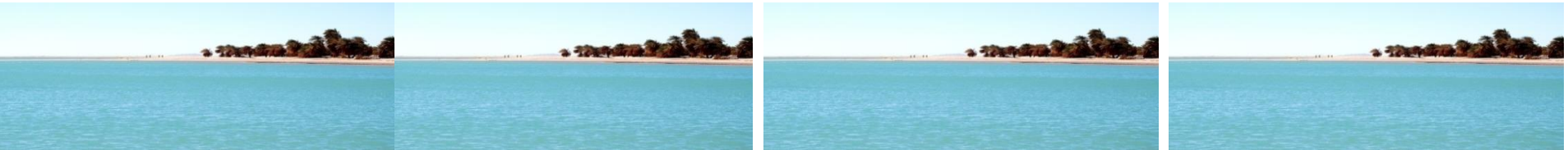


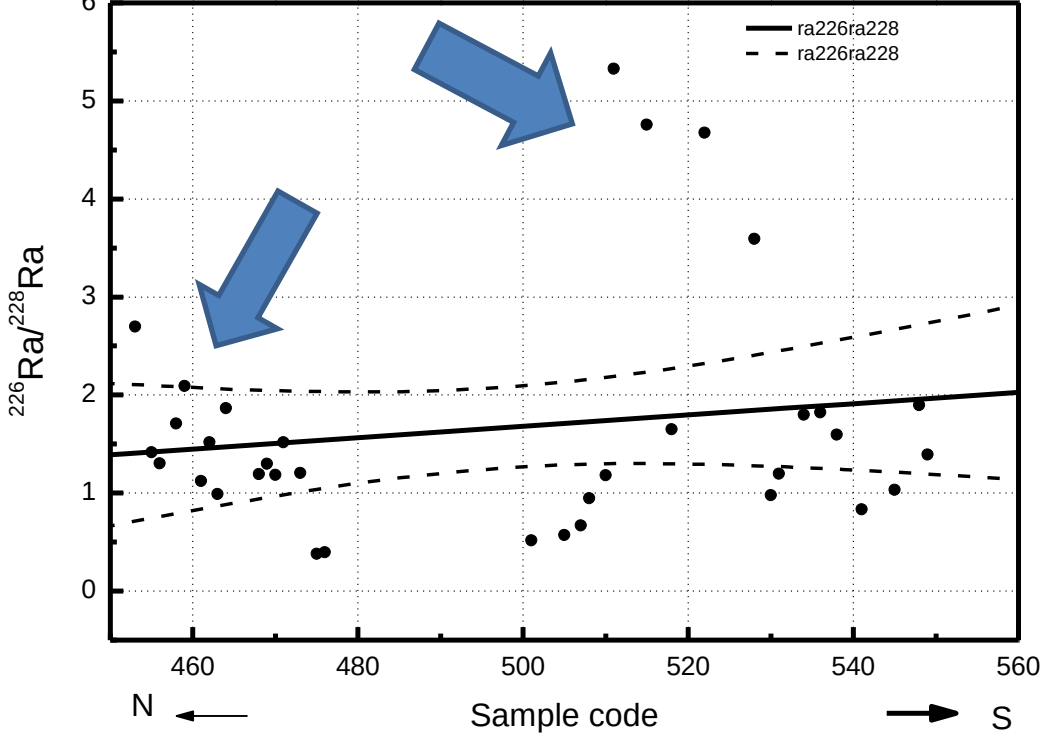


R= -0.4
K-40
CODE
1000
800
600
400
200
0
440
460
480
500
520
540
560



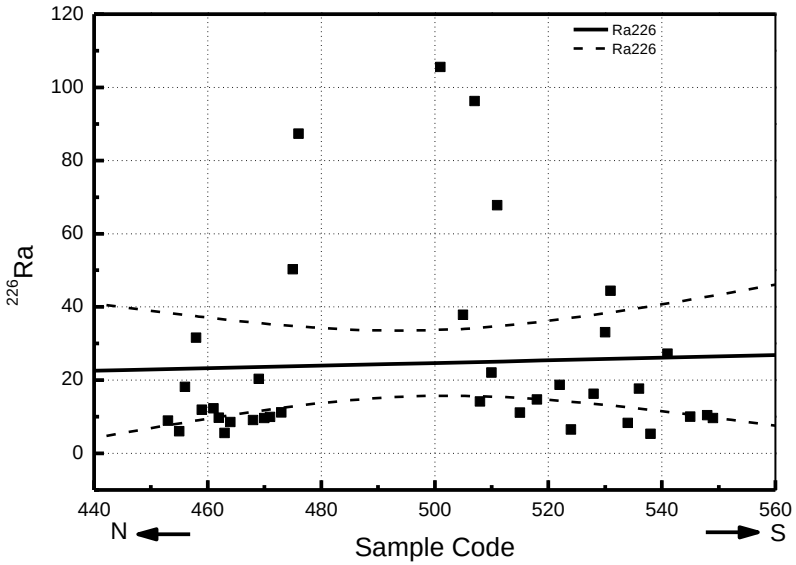


Shuqueir
N. Hurghada
Safaja
Quseir
Marsa Alam
28
27.5
27
26.5
26
25.5
33.5
34
34.5
1.4
1
0.6
1.8
2.2
2.6
3
3.4
3.8
2.6
2.2
1.8
3.4
3
5.2
5
4.8
4.6
4.4
4.2
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4

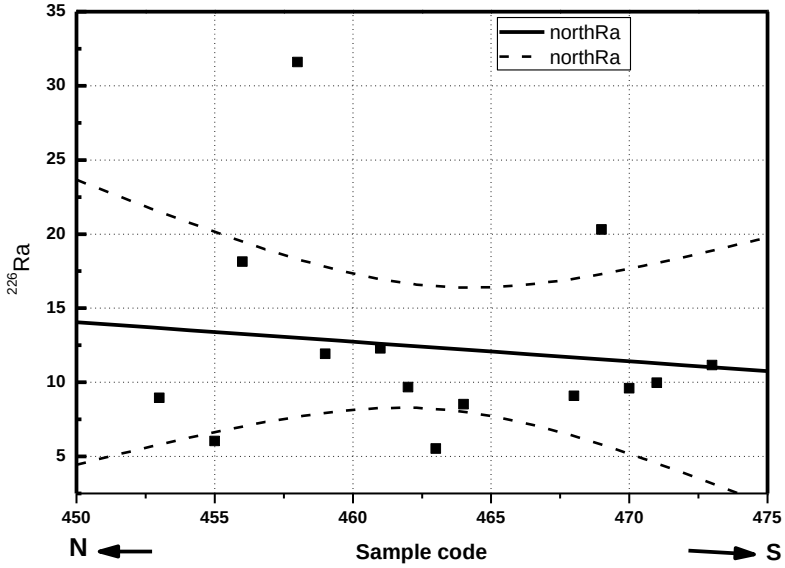

ra226ra228
ra226ra228
$^{226}Ra/^{228}Ra$
6
5
4
3
2
1
0
460
480
500
520
540
560
N
Sample code
S

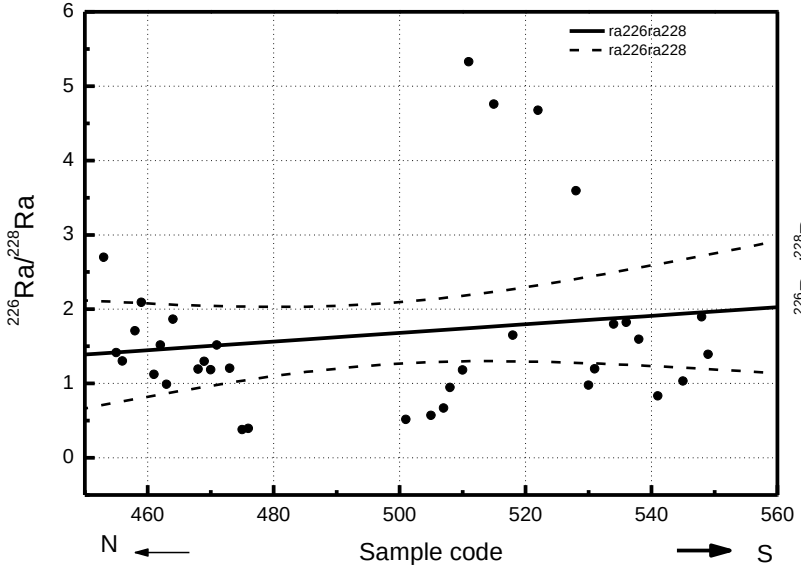


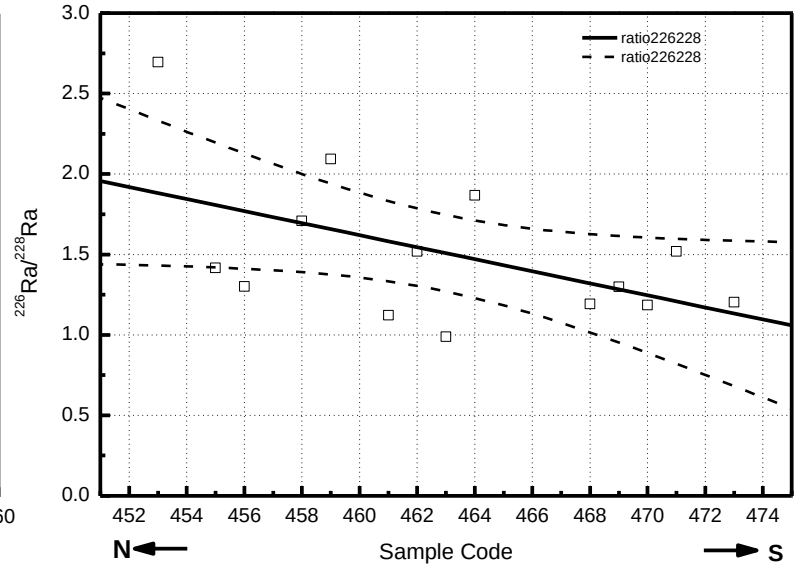


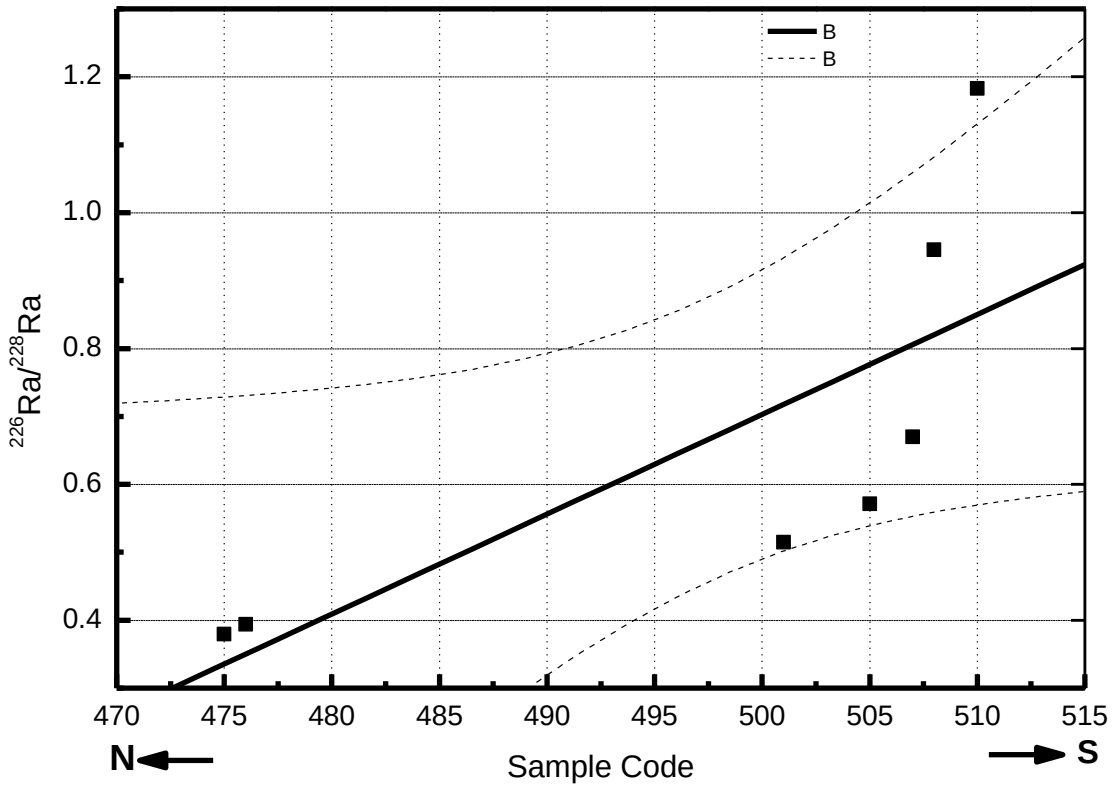
These relationships and their trend line imply the increase of $^{226}Ra/^{228}Ra$ activity ratio in the direction of Shuqeir in the North and Safaga where the oil exploration and phosphate mining activities are located.


Ra226
Ra226
226Ra
120
100
80
60
40
20
0
440
460
480
500
520
540
560
N
S
Sample Code


northRa
northRa
226Ra
35
30
25
20
15
10
5
450
455
460
465
470
475
N
S
Sample code


ra226ra228
ra226ra228
226Ra/228Ra
6
5
4
3
2
1
0
460
480
500
520
540
560
N
S
Sample code

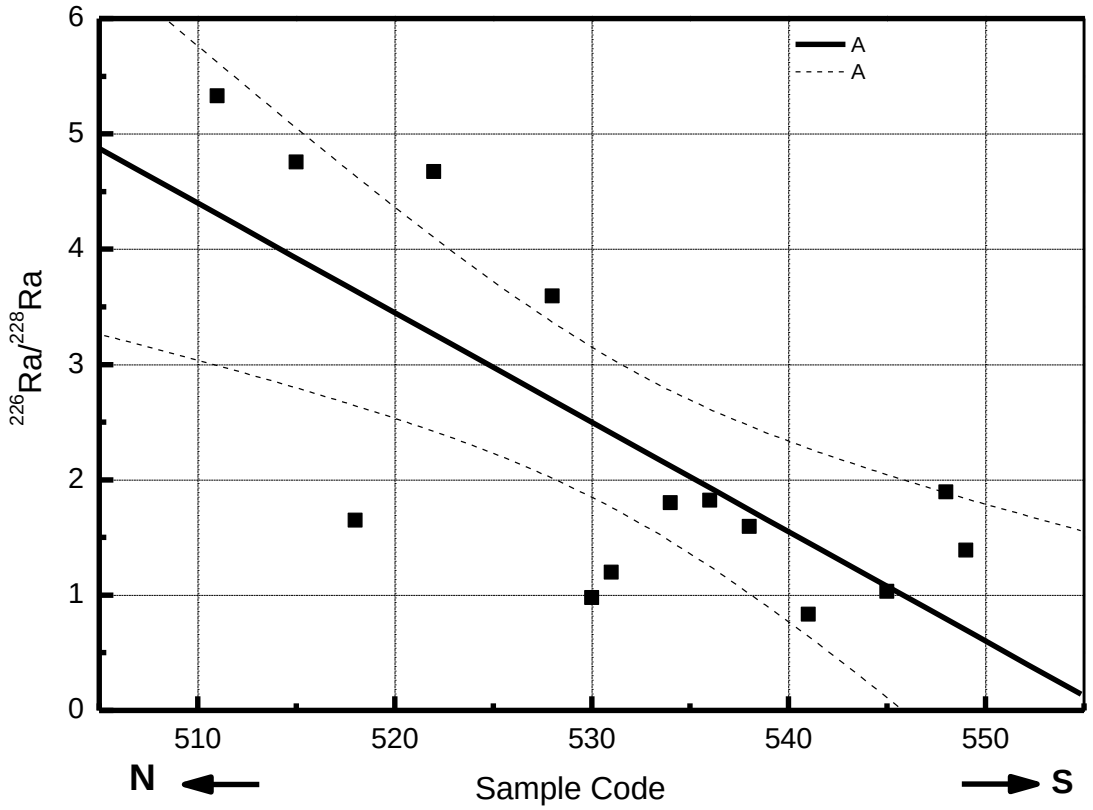

ratio226228
ratio226228
226Ra/228Ra
3.0
2.5
2.0
1.5
1.0
0.5
0.0
452
454
456
458
460
462
464
466
468
470
472
474
N
S
Sample Code

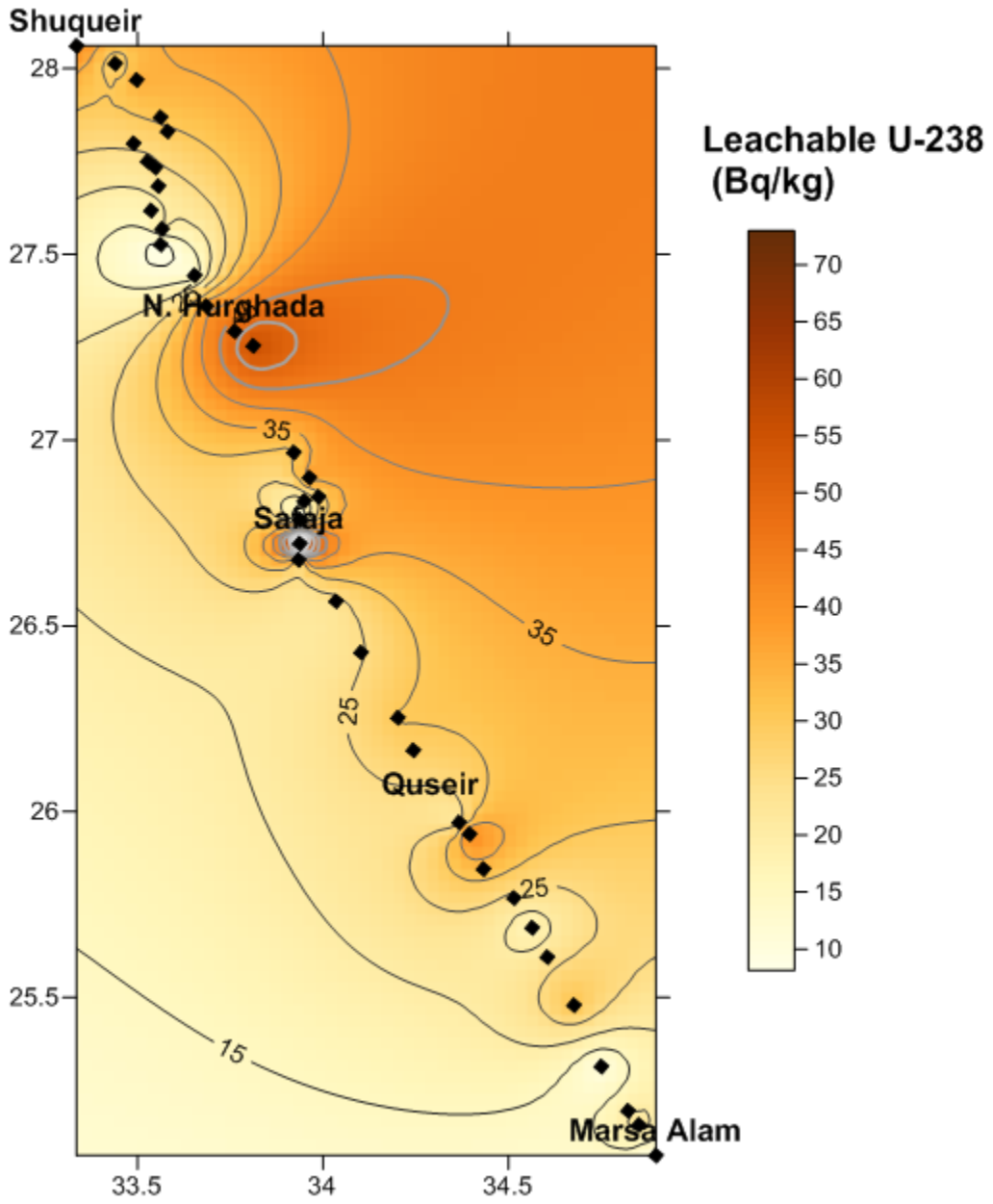


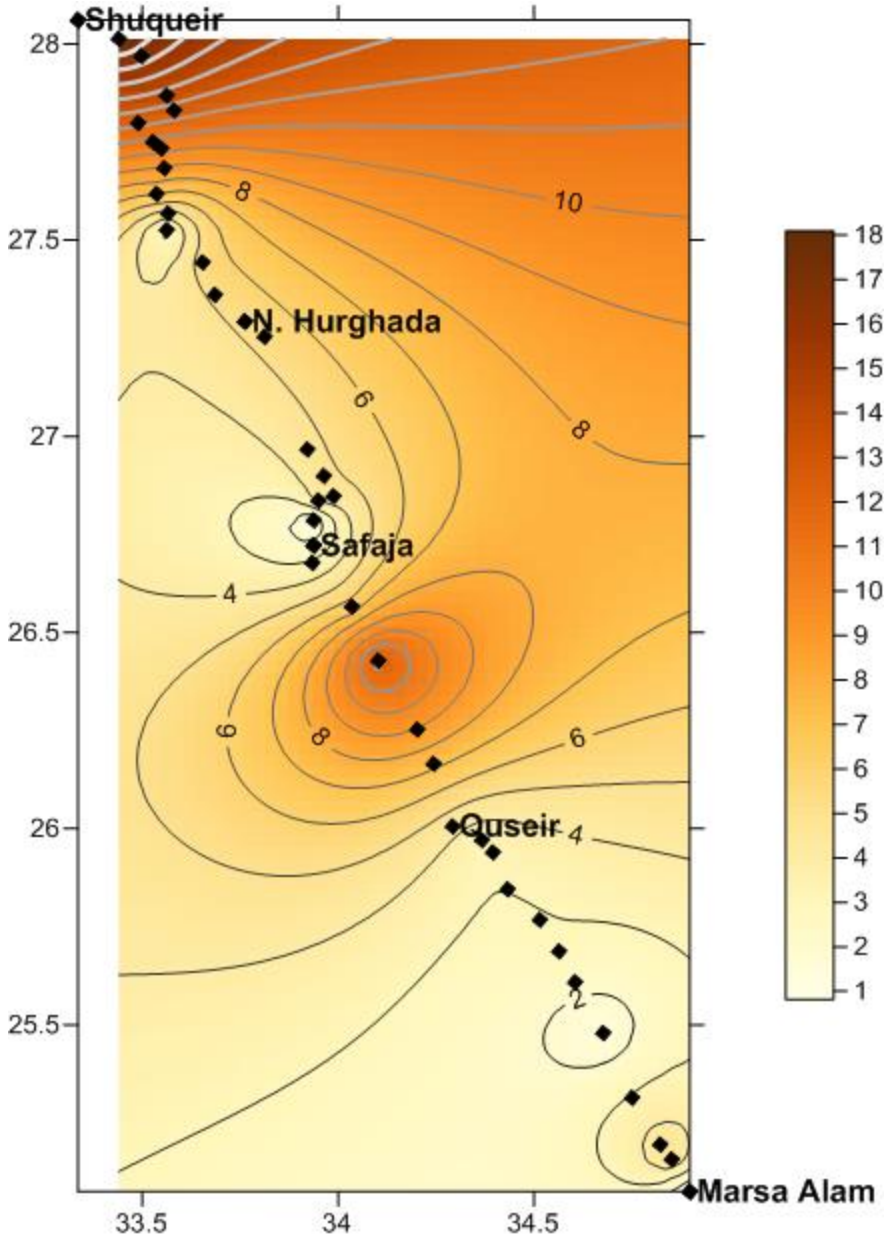
The lowest activity ratios of $^{226}Ra/^{228}Ra$ were found in the Hurghada - Sharm El-Naga region (codes, 475-507) with average value of 0.51 .

That could be explained due to the presence of black sands, which are enriched in the mineral monazite containing a significant amount of ^{232}Th (^{228}Ra). The enrichment occurs because the specific gravity of monazite allows its concentration along beaches where lighter materials are swept away

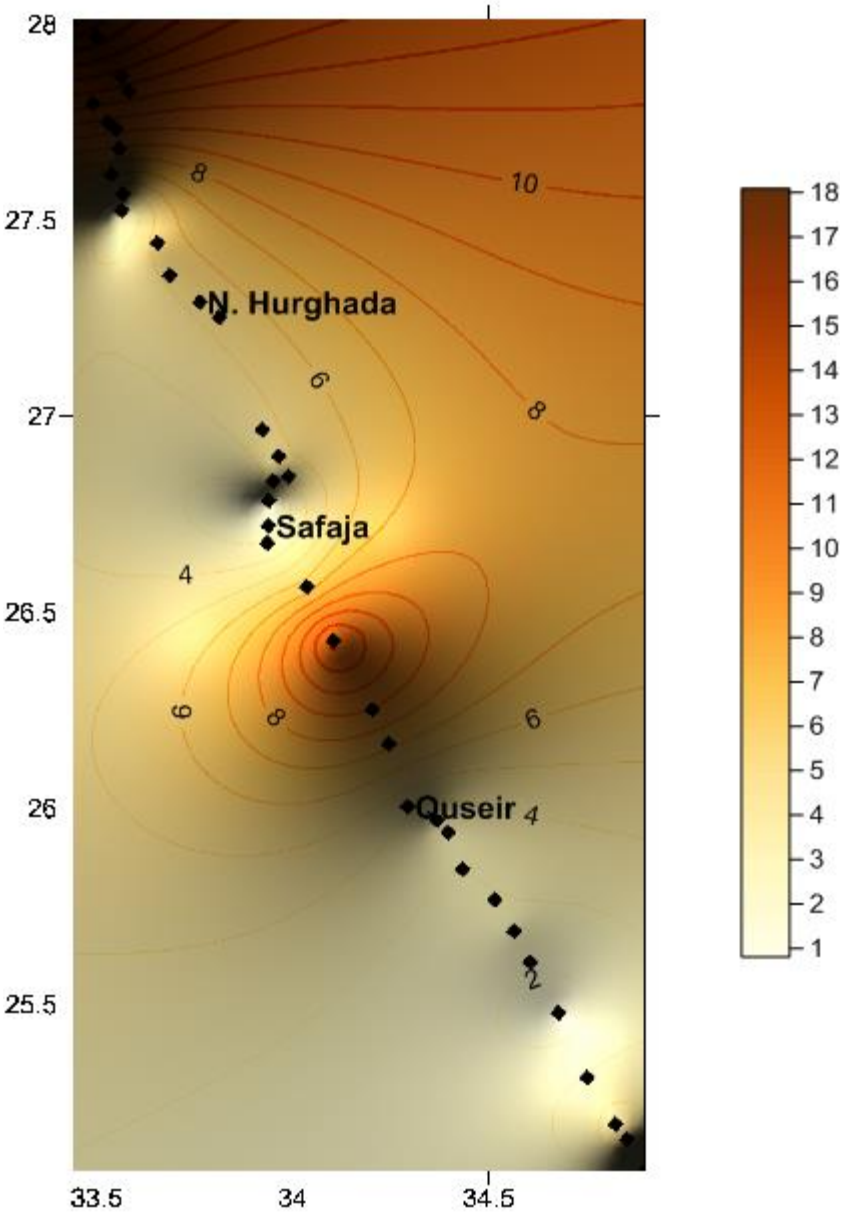
In Safaga- Qusier region (sample codes 512-528) the average activity ratio of $^{226}Ra/^{228}Ra$ was 3.68. The high average activity ratio of $^{226}Ra/^{228}Ra$ could be explained due to the phosphate mining activities in Safaga-Quseir region where the concentration of ^{238}U and its decay products tend to be elevated in phosphate deposit.



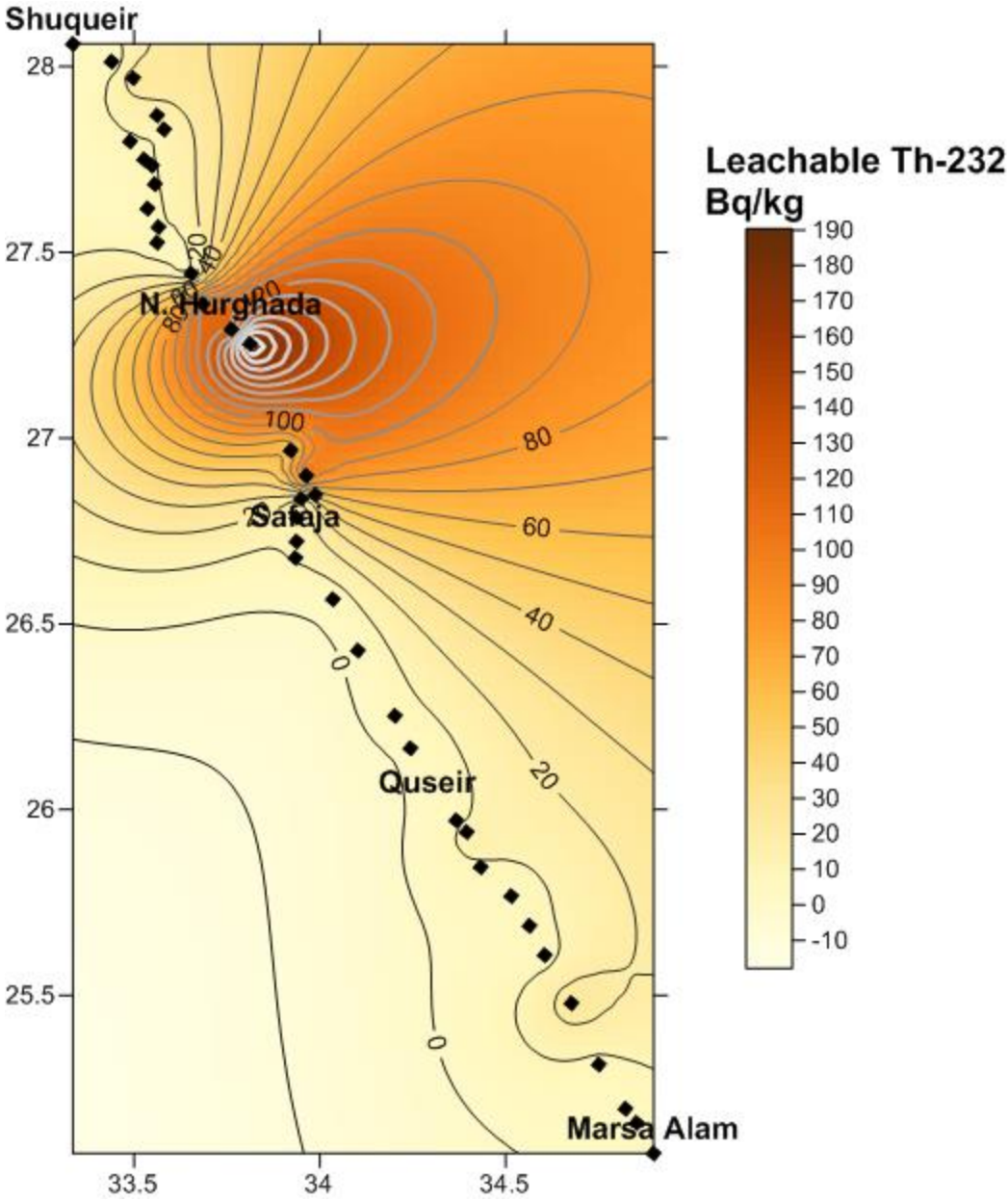

Shuqueir
28
27.5
27
26.5
26
25.5
N. Hurghada
Safaja
Quseir
Marsa Alam
35
35
25
25
15
33.5
34
34.5
Leachable U-238
(Bq/kg)
70
65
60
55
50
45
40
35
30
25
20
15
10


Shuqueir
N. Hurghada
Safaja
Quseir
Marsa Alam
28
27.5
27
26.5
26
25.5
33.5
34
34.5
8
10
6
4
2
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1

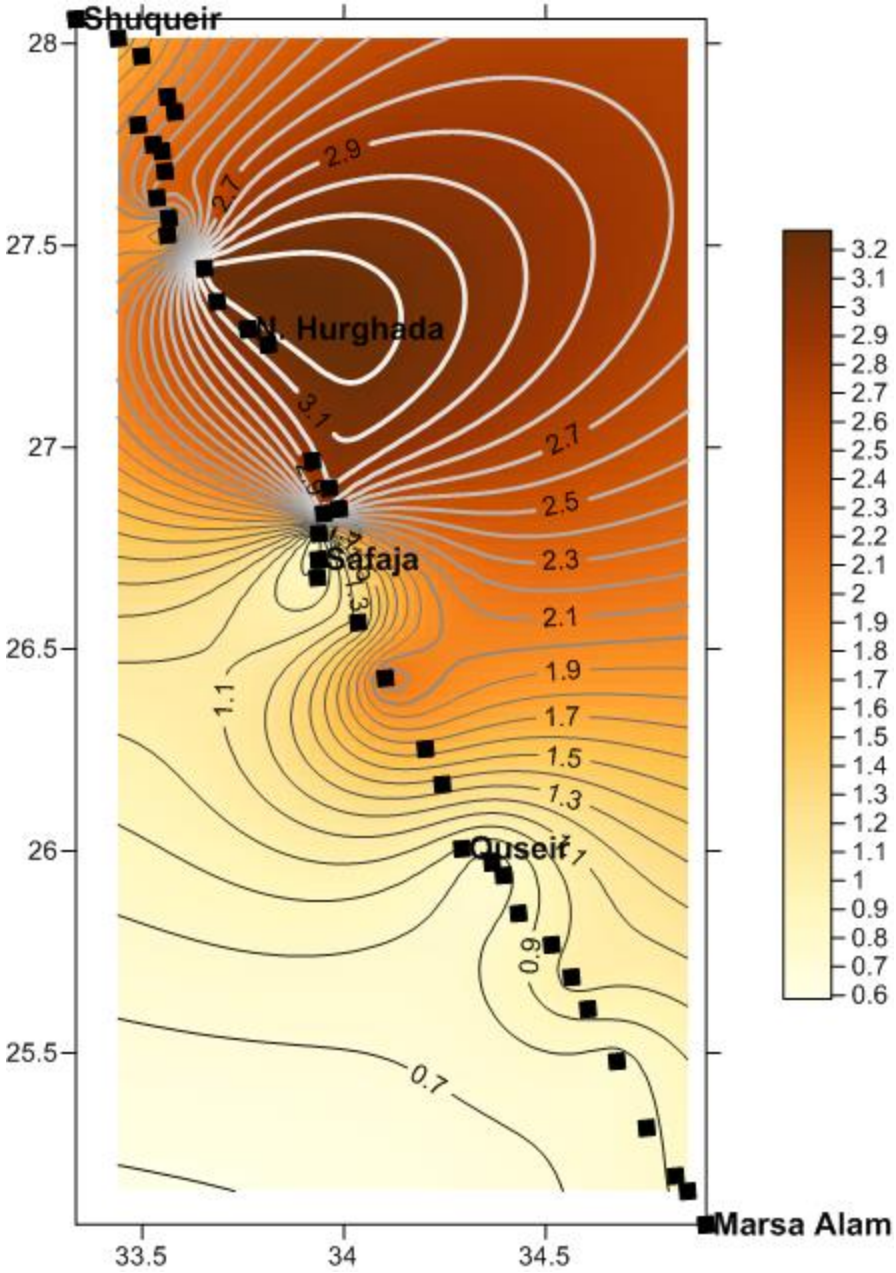
EF of U-238

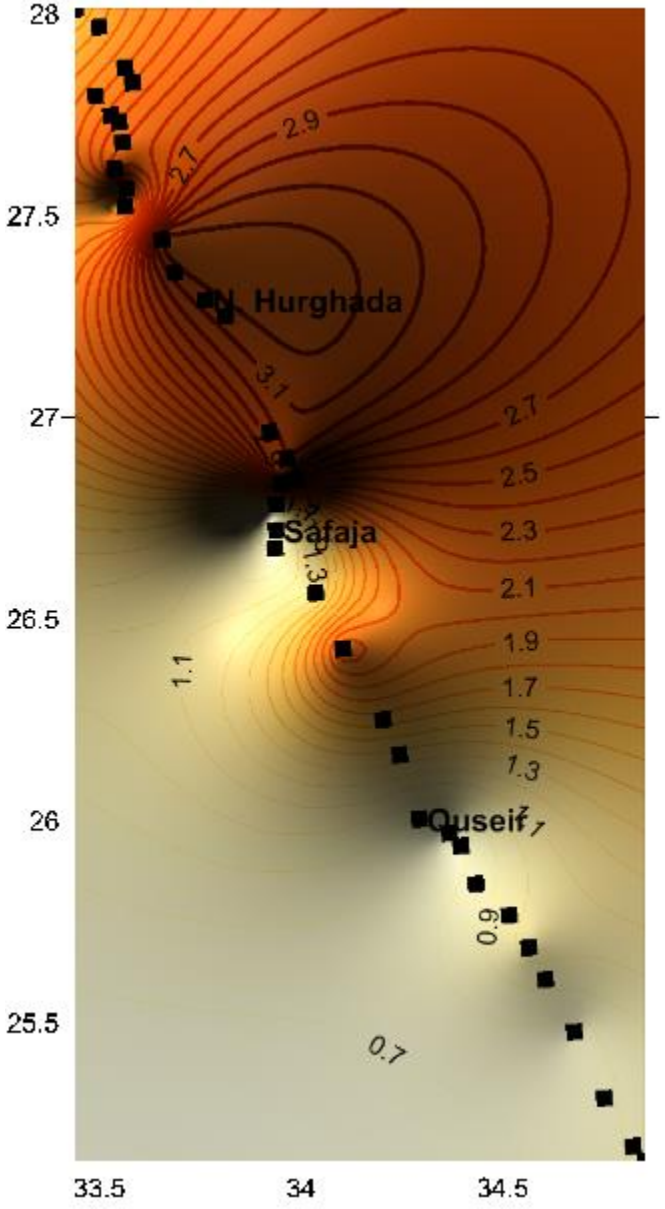

N. Hurghada
Safaja
Quseir
28
27.5
27
26.5
26
25.5
33.5
34
34.5
8
10
6
4
2
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1

the presence of black sands, which are enriched in the mineral monazite containing a significant amount of ^{232}Th (^{228}Ra).



EF of Th-232

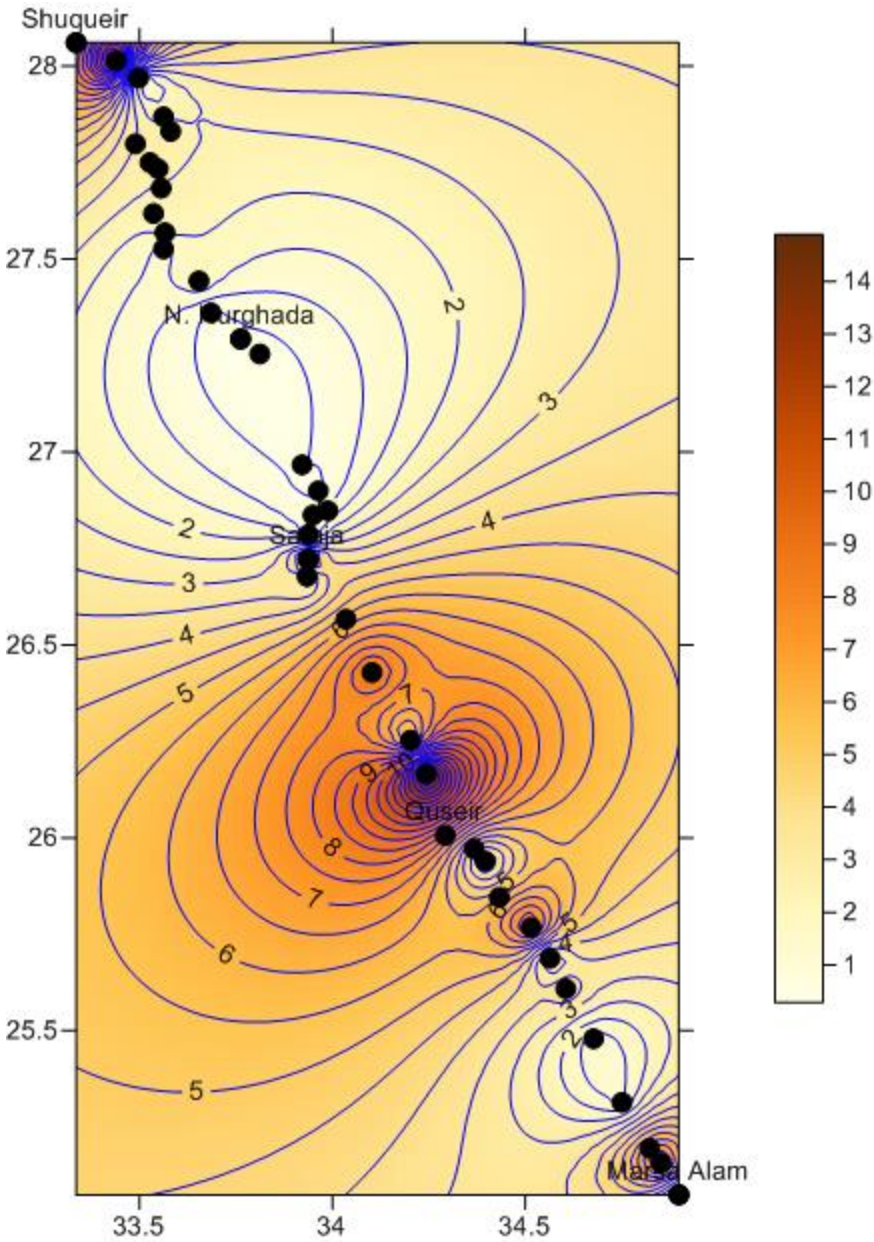

Shuqueir
N. Hurghada
Safaja
Quseir
Marsa Alam
28
27.5
27
26.5
26
25.5
33.5
34
34.5
3.2
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6


N. Hurghada
Safaja
Quseir
28
27.5
27
26.5
26
25.5
33.5
34
34.5

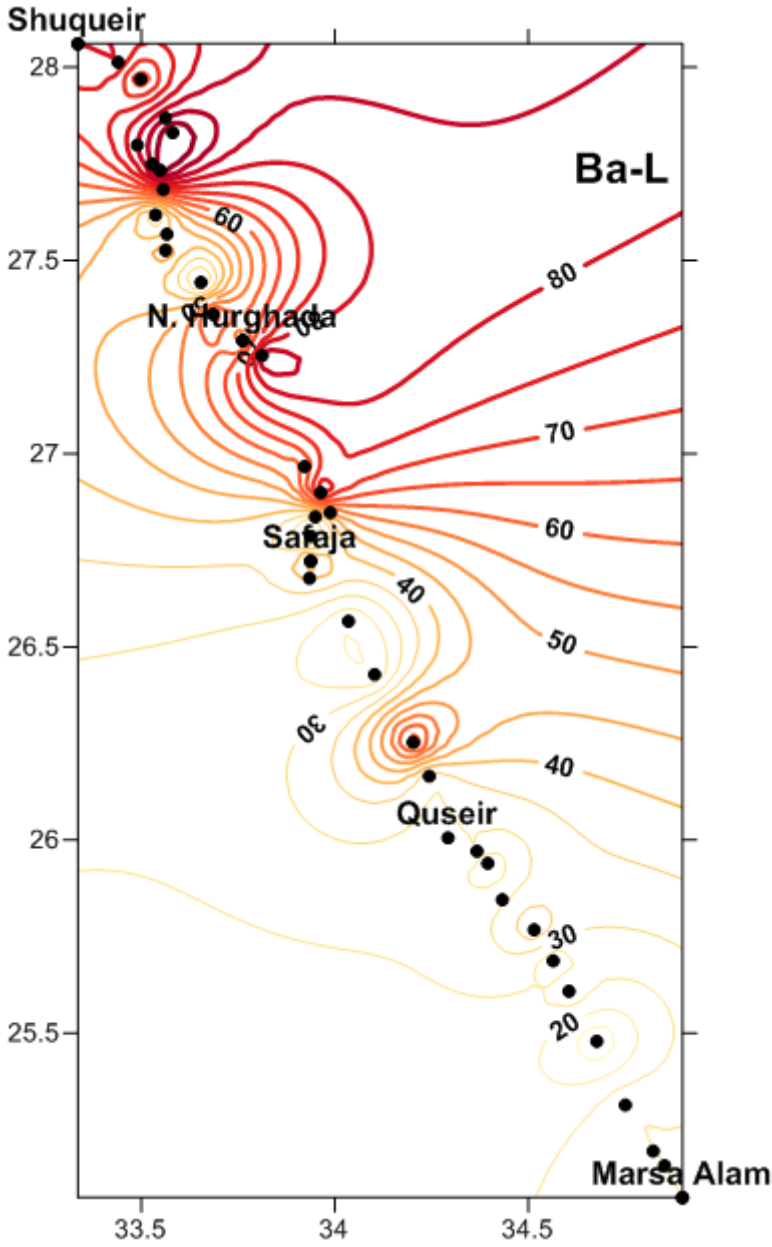
Activity ratio of leachable U-238/Th-232

The activity ratios of $^{238}U/^{232}Th$ varied widely over ten fold (0.3-15) with an average value of 3.7.

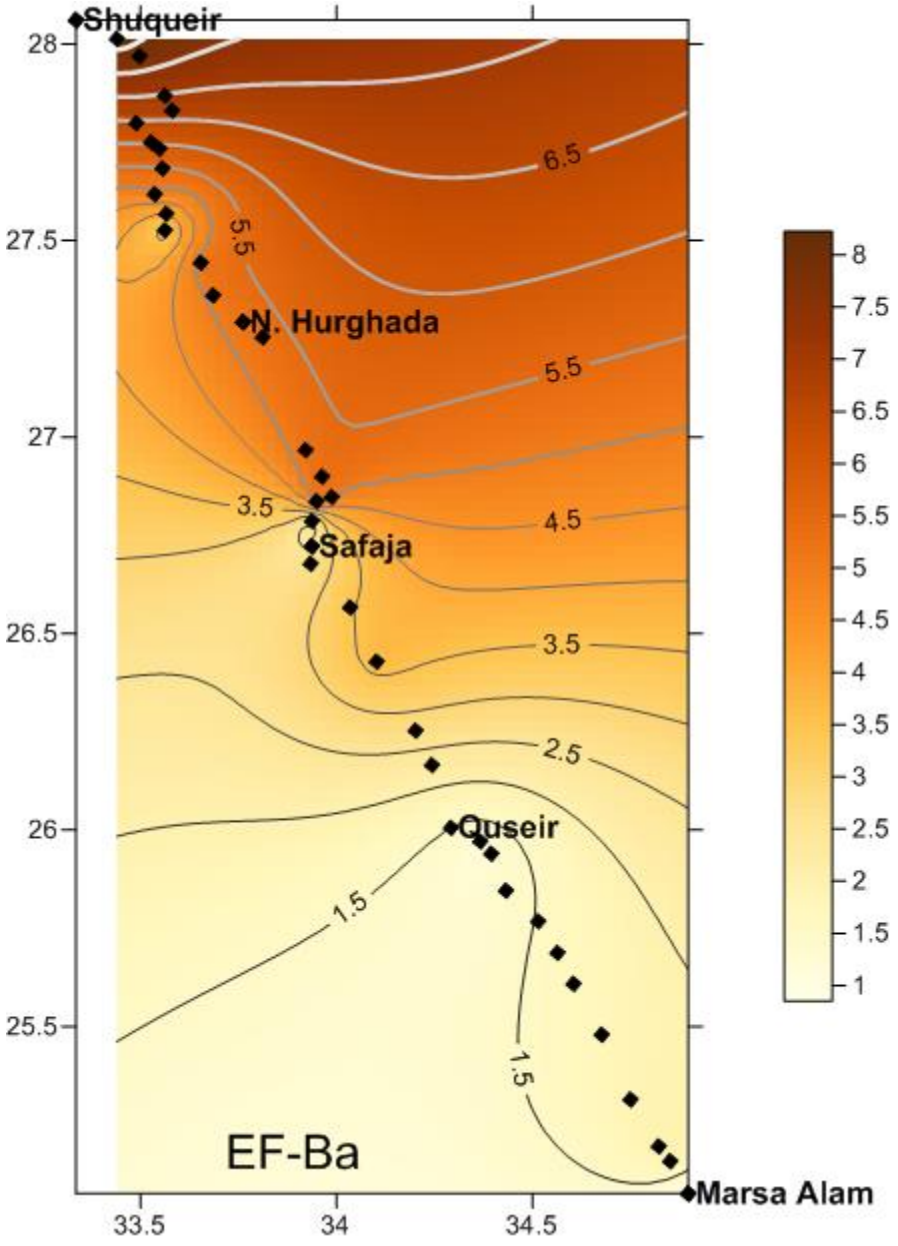
The difference in their geo-chemical behaviour in marine environment is very obvious in the Red Sea bottom sediment where $^{238}U/^{232}Th$ average activity ratio is 40 (Khatir et al., 1998).



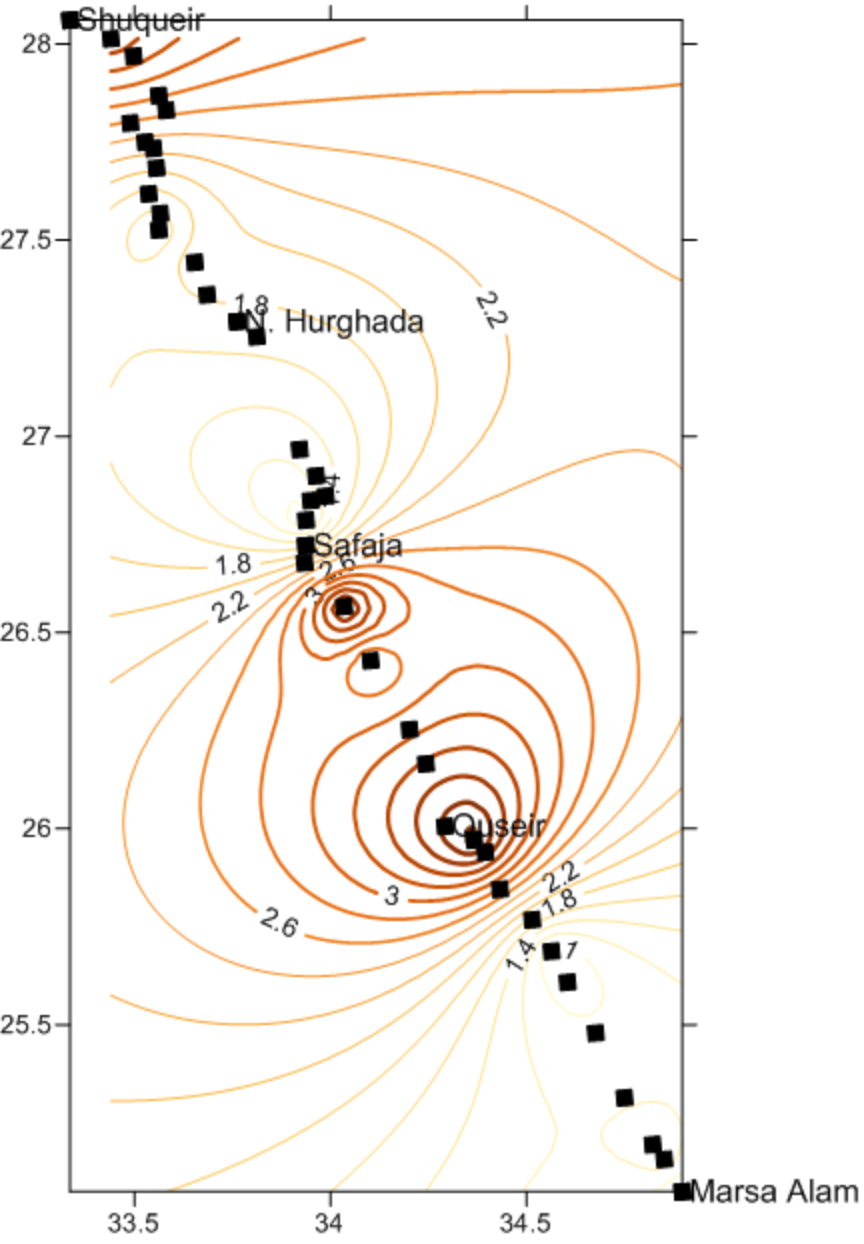
Distribution pattern of leachable Ba (ppm)

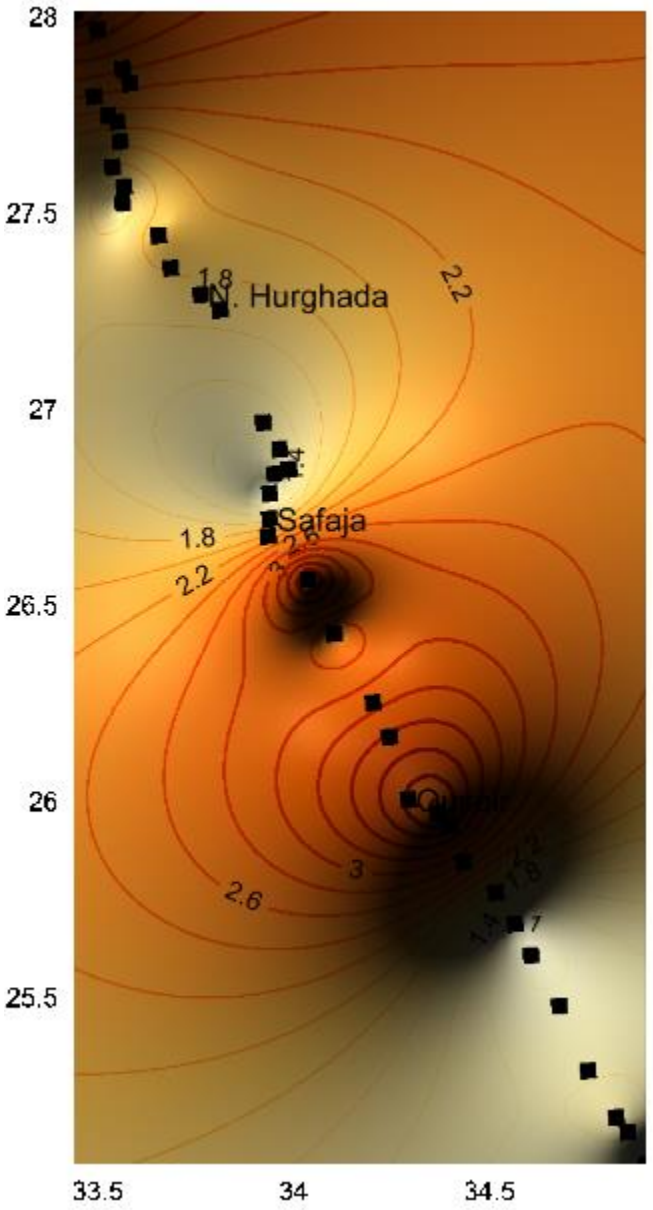


Enrichment Factor for Ba-L

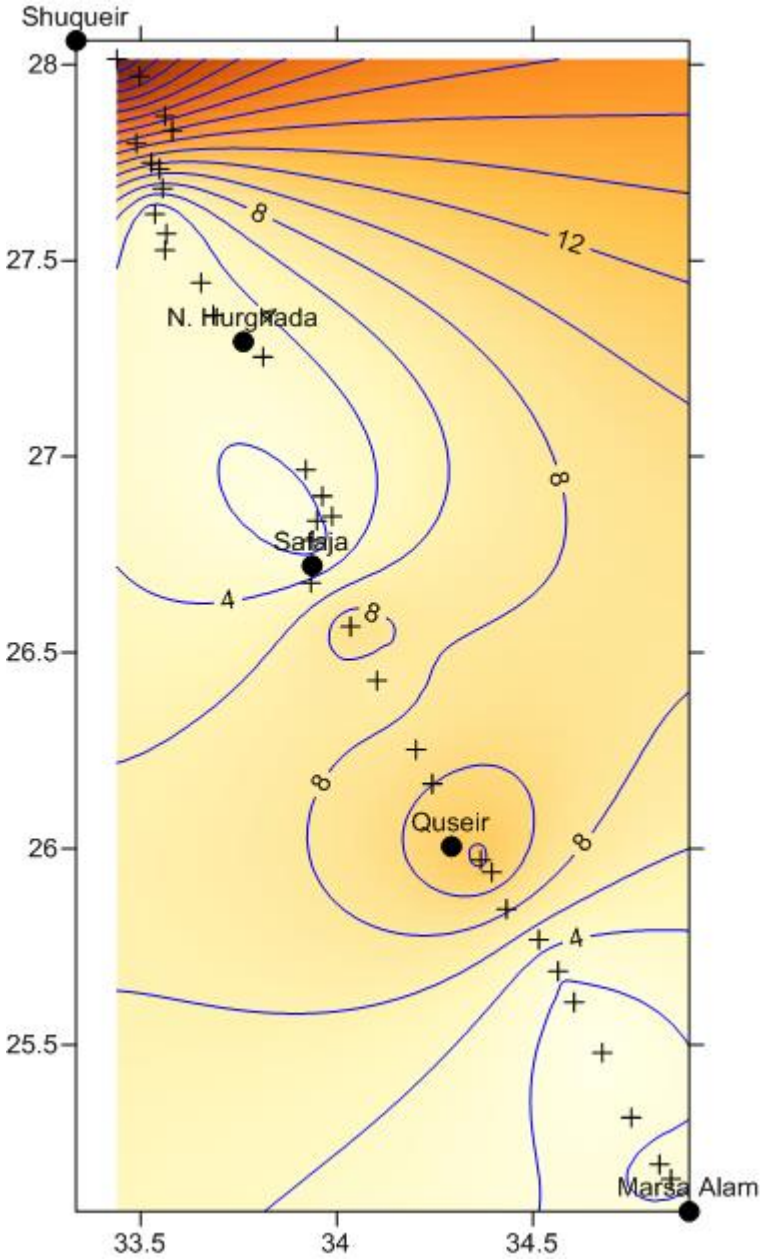


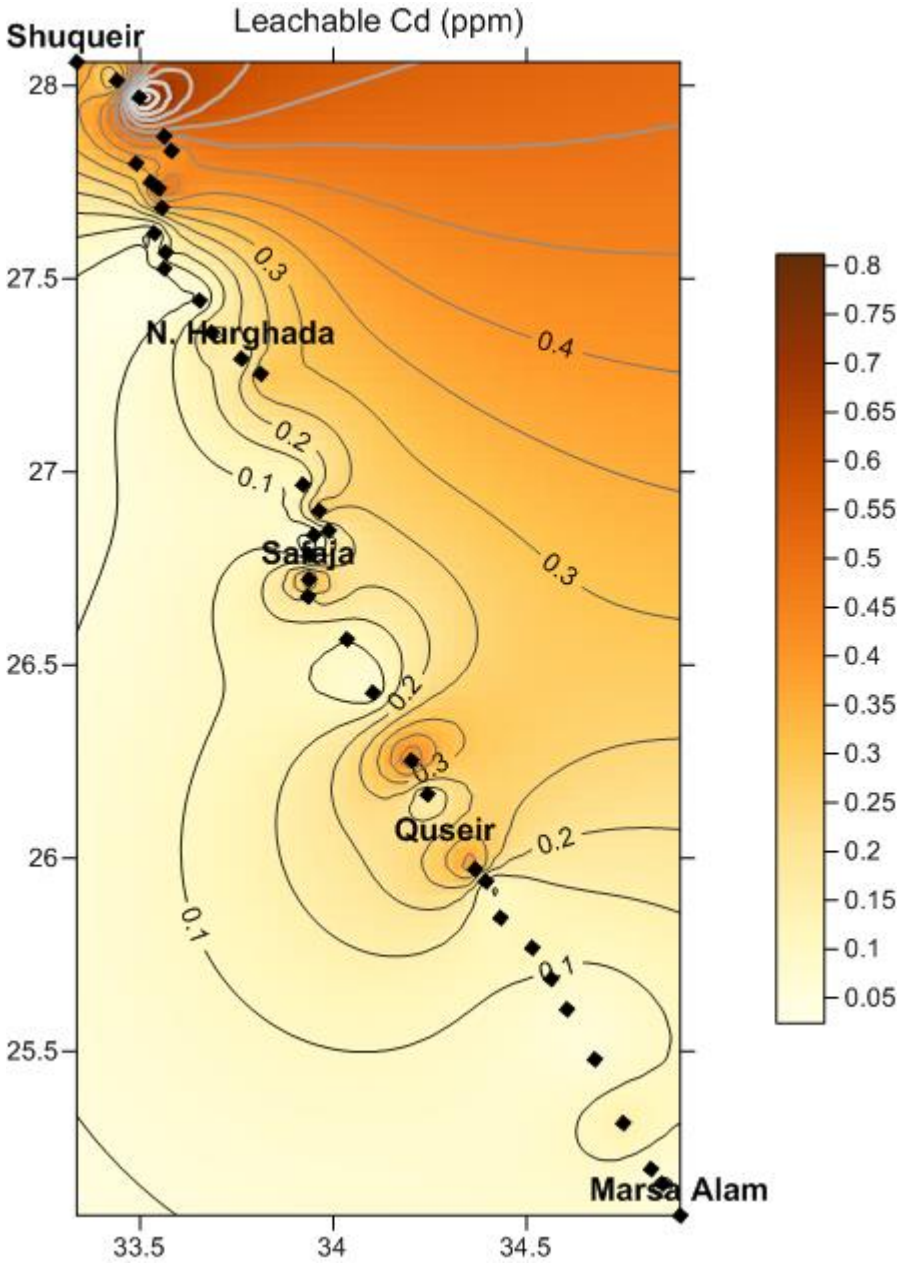
EF of leachable P





EF of leachable Cd





CONCLUSIONS

- ***Investigation of the radio-ecological aspects of the Egyptian coast of the Red Sea and the radiological impacts of the non-nuclear industries (oil industries and phosphate mining) on the coastal environment are needed.***

- **Our results imply that there is an indication of the radiological impacts of the oil industries in the Northern region of the Red Sea Coast and phosphate mining in Safaga- Qusier region.**

To help **policy makers** to indentify the anthropogenic impacts and **better assess** the needs **for remediation** .

SAFE AND PROTTECT THE ENVIRONMENT

Thank you for your attention!