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Environmental study for Mediterranean Sea ecosystem using seagrass and algae samples with Neutron Activation Analysis

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OUTLINE

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05 CONCLUSION

1

AIM OF THIS WORK

AIM OF THIS WORK:

- The determination of elemental content: The study focuses on analyzing the elemental composition of marine macrophytes found along the Mediterranean Sea coast of Egypt. This analysis aims to provide valuable insights into the presence and levels of various elements within these macrophytes.

- Assessing polluting agents and their impact: The main objective of the study is to assess the polluting agents present in the marine ecosystem of the study area. By examining the elemental content of the collected macrophytes, the study aims to reflect the general background of pollution in the water environment and gain a deeper understanding of its potential impact on the surrounding ecosystem.

2

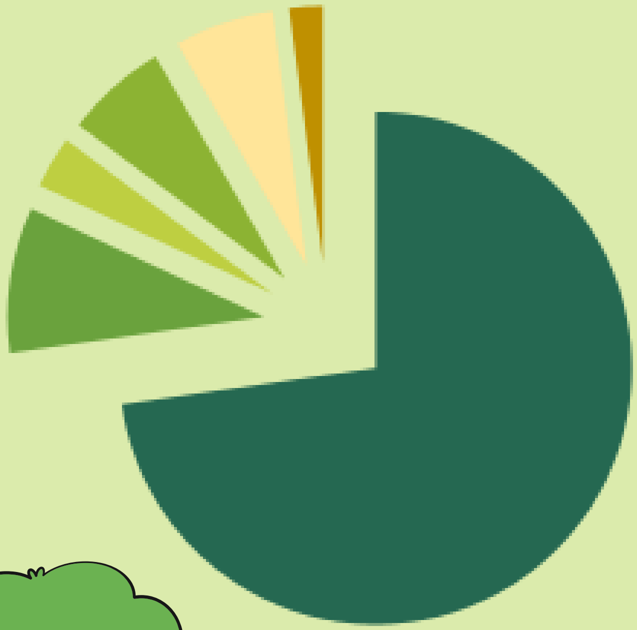
INTRODUCTION

WATER RESOURCES IN EGYPT

Do you know what are the main sources of water in Egypt:

- The Nile River is the main source
- Agricultural drainage
- Ground water in Delta

WATER RESOURCES IN EGYPT IN 2010



55%	Nile River
7%	Agricultutral drainage
2.5%	Sewage water
4.7%	Drainage water reuse in lower Egypt
4.8%	Ground water in Delta and Nile river valley
1.1%	Rainfall and Ground water in desert

PRESSURE ON WATER RESOURCES IN EGYPT

100,000,000

Sewage driange to water

Factories drainage to water

Dead fish on NileRiver 2016

Dead Jelly fish on North coast 2017

Why Algae and Sea Grass samples❓

Since marine macroalgae have been found to be an excellent biomonitor for trace elements, the use of a biomonitor is preferable when monitoring coastal habitats. Additionally, marine species are used to reflect the level of metals in aquatic systems rather as detecting the concentration of metals in sediment and seawater samples since the concentration of metals in seawater is very low, may be below the limit of detection, and exhibits a wide range of changes.

3

Experimental work

Experimental Work

- Sampling locations
- Sampling collection and preparation
- Samples measurments

Sampling locations

Map illustrating Sampling sites:

1-AGIBA, MATROUH

2-ELOBAYED, MATROUH

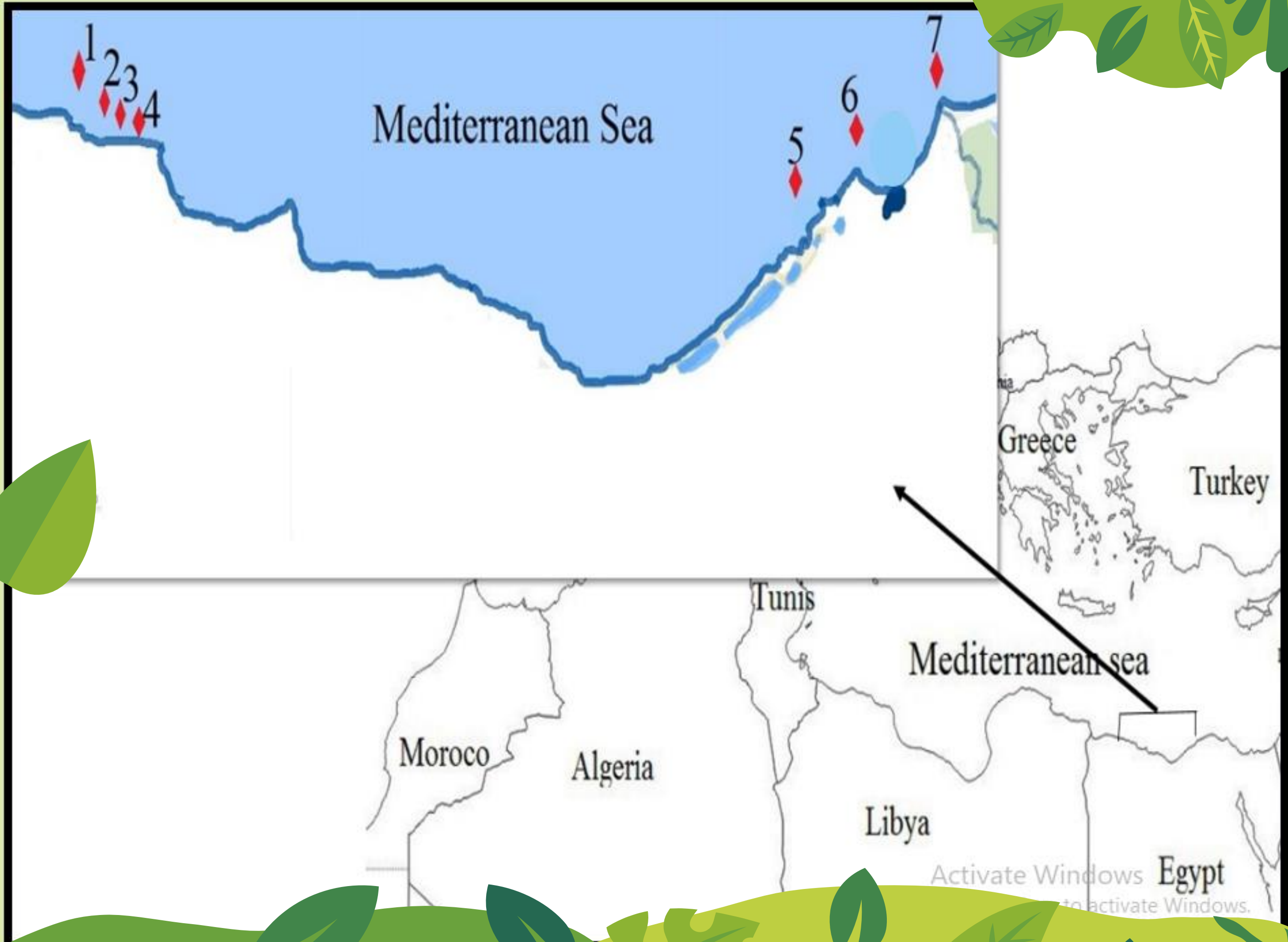
3-CLEOPATRA, MATROUH

4-ROMIL, MATROUH

5-CITADEL, ALEX.

6- ABO-QIR, ALEX.

7-RAHEED, DELTA



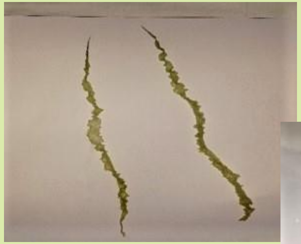
Sampling locations and species collected

1	**Agiba, Marsa Matrouh**	Cladophora sp
2	**El Obayed, Marsa Matrouh**	Posidonia balls, Sargasum sp.
3	**Cleopatra, Marsa Matrouh**	Cystoseira sp , Posidonia balls
4	**Romil, Marsa Matrouh**	Cymodocea nodosa, Cladophora sp.
5	**Citadel, Alexandria**	Gelidium pusillum
6	**Abo-Qir, Alexandria**	Hypnea sp, Ulva Intstinalis, Amphiroa sp., Entermorpha sp.
7	**Rasheed, Delta**	Entermorpha sp.

Sampling collection and preparation

Sampling Collection and preparation:

- **13 samples od marine algae and sea grass were collected from 7 station along Mediterranean sea north coast of Egypt during 2015-2016.**
- Samples were collected by hand on the depth 0.5 to 1.5 m, rinsed with ambient water and cleaned from epiphytes, then kept in a polyethylene bags and transferred to the laboratory in an ice-box. In the laboratory samples were rinsed with distilled water and dried till constant weight at 40˚C during 24 hours then manually homogenized in agate mortar.

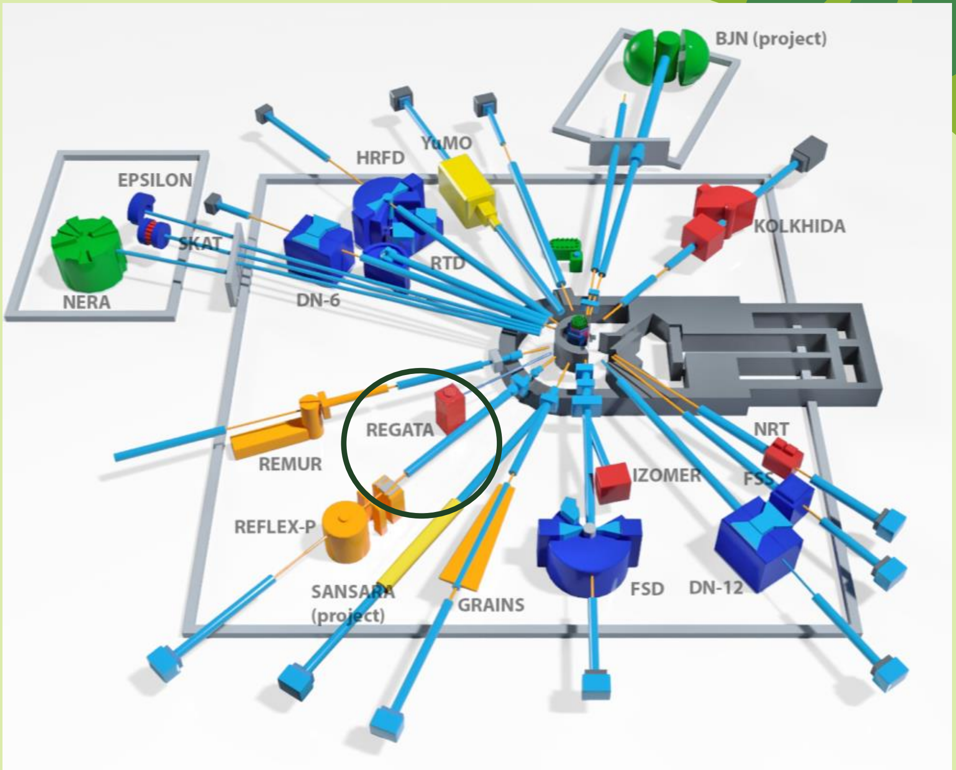





Samples measurments

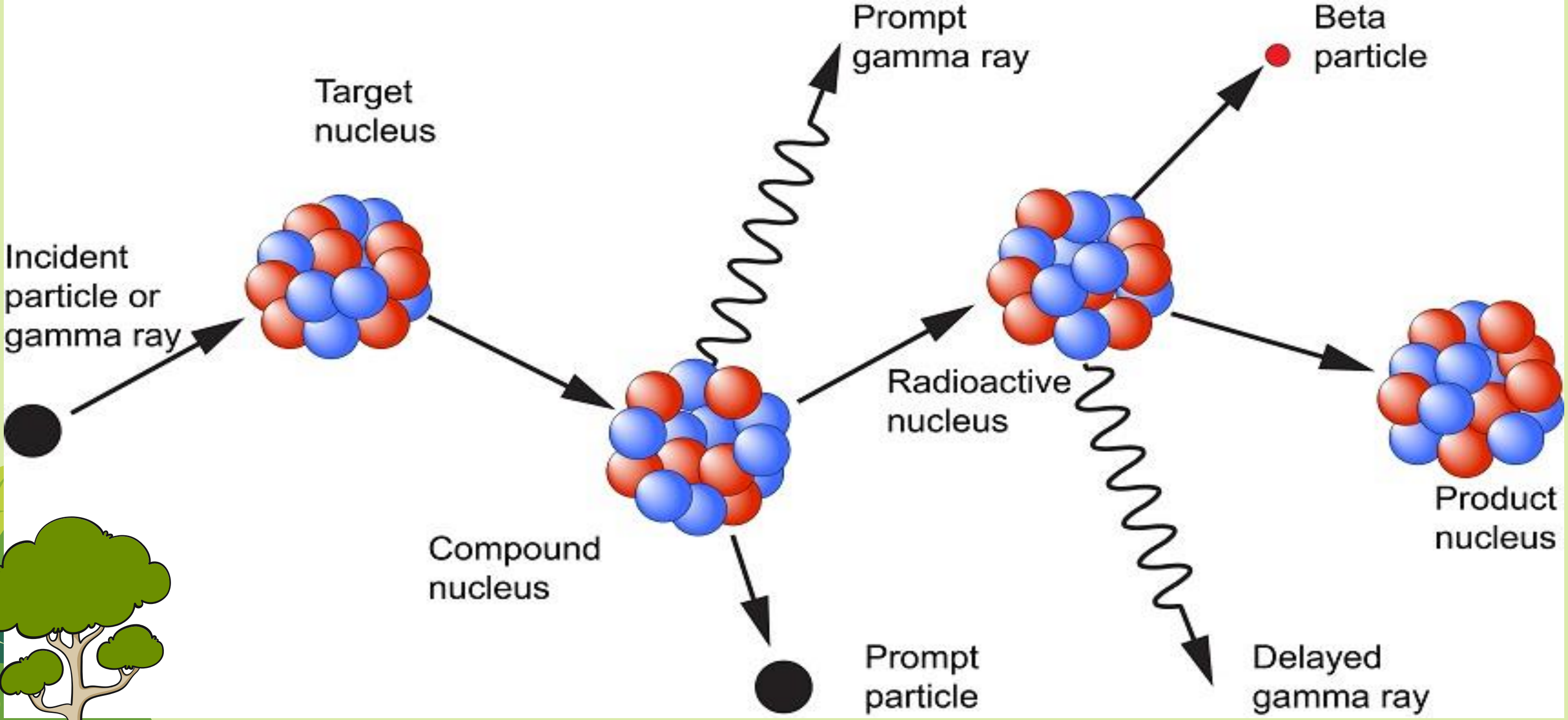
- Samples were analyzed with Neutron activation analysis that was performed in the Frank Laboratory of Neutron Physics, IBR-2 of the JINR.

- Samples are compressed in special containers at 3-6 atm. pressure and connected to the REGATA pneumatic system .



Layout of pulsed fast reactor IBR-2 at JINR in Dubna

The following scheme illustrates the neutron capture process and gamma ray emitted after irradiation process:



SOME NAA FEATURES

Neutron Activation analysis

- Neutron activation analysis is an isotope specific analytical technique for the qualitative and quantitative determination of elemental content and is considered as highly sensitive analytical technique
- It was first performed in 1936 by Georg de Hevesy and Hidle Lev.
- NAA is considered one the primary analytical techniques.
- It is also nondestructive analytical method, that save the samples as analysis is done without any use of chemical preparation prior to the analysis.
- Multi-elemental analysis at the same time and in the same process.
- NAA has a good selectivity due to specific nuclear physics characteristics of the elements.
- NAA Measures wide range of elements including rare earth elements.
- Easy sample preparation method.
- Good accuracy + 10-15% in determination of low concentrations (ppm).

Analytical capabilities and detection limits for elements by NAA:

Fast Neutron Activation analysis

Prompt Gamma Activation Analysis

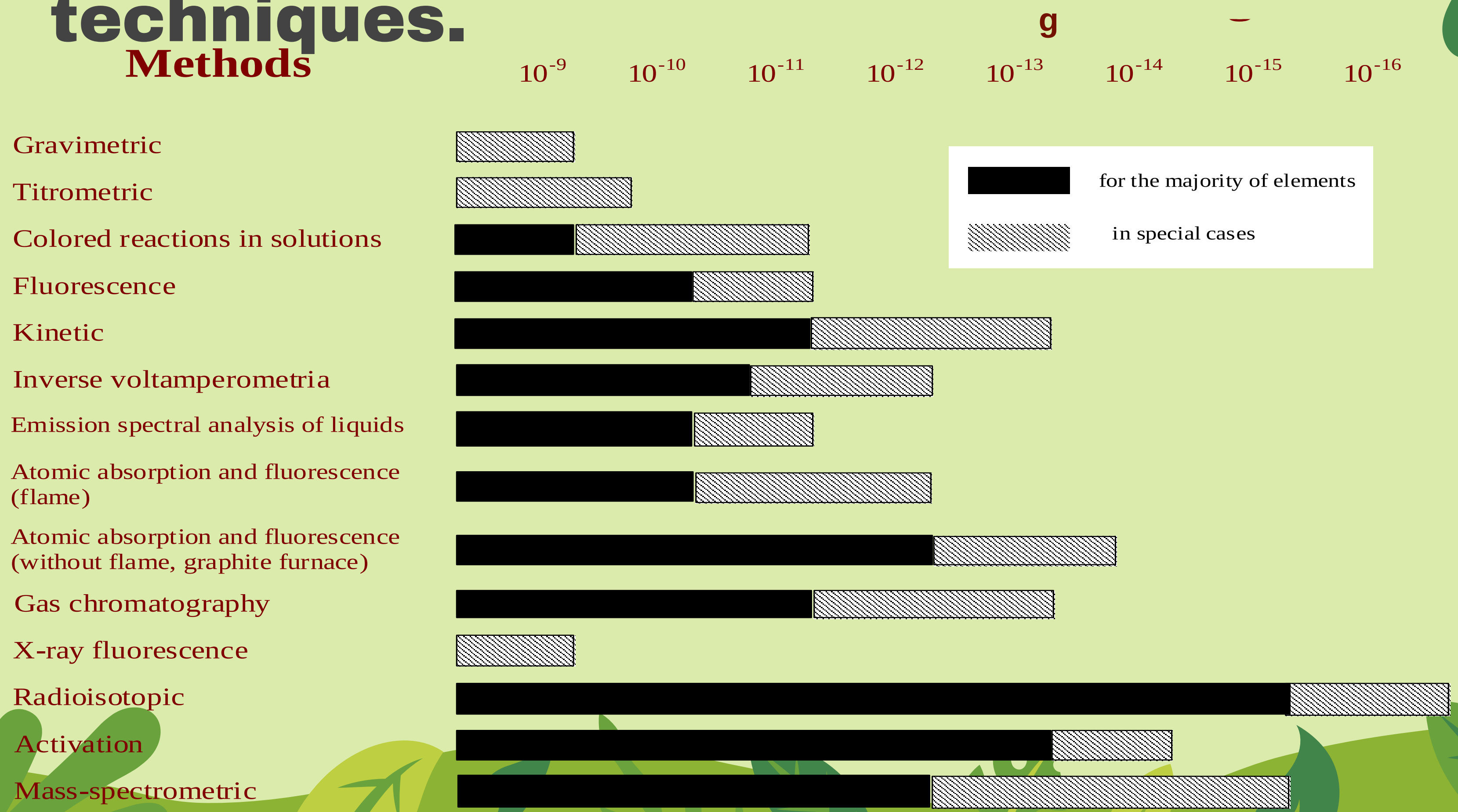
Thermal Neutron Activation analysis

Not done by NAA.

*Numbers represent ppm.

H 1																	He
Li	Be											B 1	C	N 500	O 500	F 1000	Ne 100
Na 1.0	Mg 100											Al 10	Si 1000	P 1000	S	Cl 1.0	Ar 0.1
K 10	Ca 1000	Sc 0.1	Ti 100	V 1.0	Cr 10	Mn 0.1	Fe 100	Co 1.0	Ni 100	Cu 10	Zn 10	Ga 1.0	Ge 100	As 0.01	Se 0.1	Br 0.1	Kr 1.0
Rb 10	Sr 100	Y 100	Zr 100	Nb 1000	Mo 10	Tc	Ru 10	Rh 100	Pd 10	Ag 1.0	Cd 10	In 0.01	Sn 10	Sb 0.1	Te 0.1	I 0.1	Xe 1.0
Cs 1.0	Ba 10	La 0.1	Hf 0.1	Ta 1.0	W 0.1	Re 1.0	Os 100	Ir 0.1	Pt 10	Au 0.01	Hg 10	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac															
			Ce 10	Pr 1.0	Nd 100	Pm	Sm 0.1	Eu 1.0	Gd 10	Tb 1.0	Dy 0.1	Ho 1.0	Er 10	Tm 1	Yb 0.1	Lu 0.01	
			Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Md	Fm	No	Lr	

Absolute Detection Limit for different techniques.



Process scheme of NAA:

STEP 1

sampling

STEP 2

Sample preparation

STEP 3

Irradiation process

STEP 4

Measurment of Gamma spectra of induced activity

STEP 5

Gamma spectra processing

STEP 5

Calculation of conenctration

IRRDIATION PROCESS

Short lived isotopes

0.3 g of samples were packed in a heat sealed poly ethylene container and irradiated in the conventional channel and irradiated for 3 min. and measured twice:

- After 2-3 min.
- After 9-10 min for 20 min.

Long Lived Isotopes

0.3 g of samples were packed in aluminum cups and were determined using epithermal neutrons in cadmium-screened irradiation channel for 5 days. and measured twice:

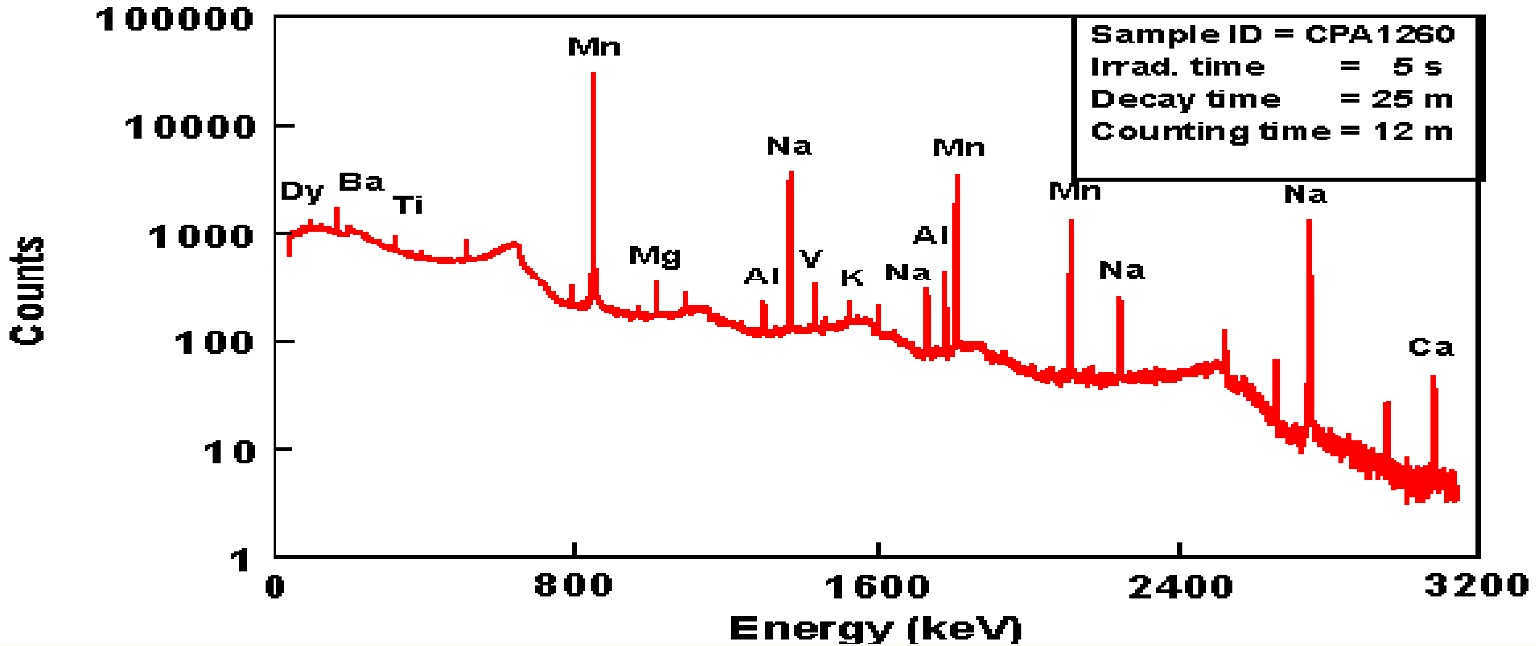
- After 4-5 days.
- After 20 days.

And measuring time from 1 to5 hr.

Measurement of Gamma spectra of induced activity:

- The gamma ray counting system for multi-elemental analysis uses a semiconductor detector.
- The system sorts the pulses in spectrum analyzers and saves the data on a computer system.-
- Ge(Li) detectors or highly pure germanium HpGe detectors are used for measuring induced gamma activity.
- The detectors have high efficiency and resolution.
- HPGe detectors have a resolution of 1.9 keV for the 60Co 1332 keV gamma line.
- The determined concentrations have errors in the range of 5% - 15% for most elements. And for elements like Zr, Mo, Ag, and Au, which have concentrations at the level of detection, the errors can be 30% or greater.

To process gamma spectra and to calculate concentrations of elements in the samples, software was used that was developed at FLNP JINR



Gamma-ray spectrum showing several short-lived elements measured:

Gamma spectra processing:

-So as to process gamma spectra and to calculate concentrations of elements in the samples, software was used that was developed at FLNP JINR.

-Quality control was ensured by simultaneous analysis of the examined samples and standard reference materials SRM 1632c (trace elements 33 in coal, National Institute of Standard and Technology (NIST)), SRM 1633b (constituent elements in coal fly ash, NIST), 1547 (peach leaves, NIST), 690CC (calcareous soil, Food and Agriculture Organization of the United Nations), 1573a (tomato leaves, NIST), SRM 433 (marine sediments, International Atomic Energy Agency) and BCR 667 (estuarine sediment, Institute for Reference Materials and Measurements) irradiated in the same conditions together with the samples under investigation.

Calculation of the concentration:

1- Concentration equation:

$$C_{sam} = C_{std} \left(A_{sam} / A_{std} \right)$$

Where:

C_{sam} is the concentration of the sample
C_{std} is the concentration of the standard
A_{sam} is the measured activity of the sample
A_{std} is the measured activity of the standard

2- The activity concentration equation used to determine concentration of elements:

$$A = \sigma\, \Phi \left(\frac{m}{M}\right) N_A\, \theta\, P_\gamma\, \xi \left(1- e^{-\lambda t_{irr}}\right) \left(1- e^{-\lambda t_{meas}}\right) \left(e^{-\lambda t_{cool}}\right)$$

Where:

A is the activity in Bq

σ is the activity cross section of the isotope under determination in cm^2

Φ is the neutron flux in (neutron/cm^2.sec)

m is the mass of the element under determination in g

M is the atomic weight of the element under determination in g/mol

θ is the abundance of the activated isotope

P_γ is the probability for emission of γ rays with energy E

ξ is the detector efficiency as a function of energy E

t_{irr} is the sample irradiation time

t_{meas} is measurement time

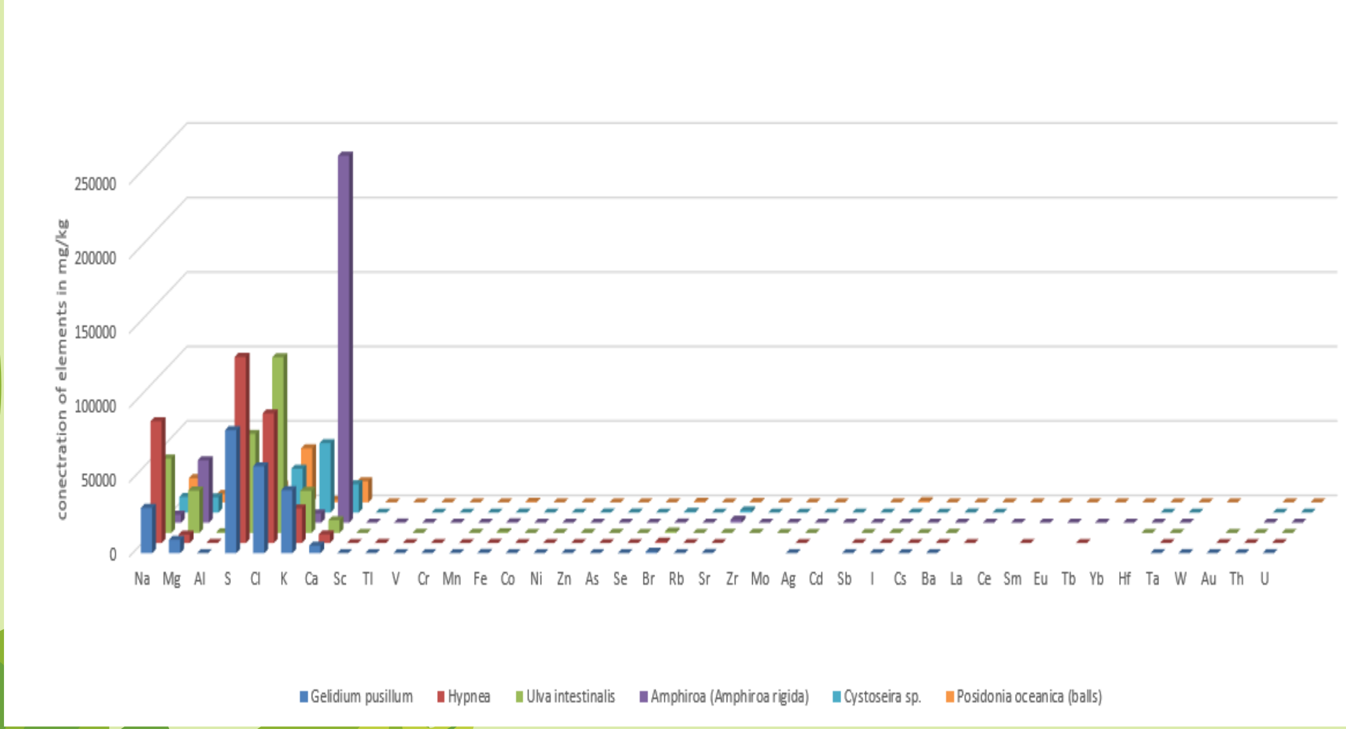
t_{cool} is sample cooling time

λ decay constant of formed isotope

3

RESULT AND DISCUSSION

For all collected samples the concentrations of Na, Mg, Al, S, Cl, K, Ca, Sc, V, Mn, Fe, Co, Ni, Zn, As, Se, Br, Rb, Sr, Ag, Sb, I, Cs, Ba, Ta, Th, and U were determined while the content of Ti, Ag, I, Mo, La, Sm, Eu, Ta, Tb, Yb and Hf in some species were below the levels of detection.



Concentration of element in mg/kg dry wt. in marine algae and seagrass collected from Med. Sea, the coast of Egypt.

- From the data it is clear that the major elements content in all species are Na, Mg, Al, S, Cl, K, Ca reflecting that they are the main nutrients for all type of macrophytes.
- The concentration of these elements varied in a wide range,like it ranges from 3310 mg/kg in Entermorpha Rasheed to 81800 mg/kg in Hypnea from Abo- Qir for Na.
- On the same way The concentration of elements in the samples collected at the same station (Abo-Qir bay) are varied greatly too. Thus the content of Na, S, Cl, Ca and Sr in Hypnea sp., Ulva intestinalis and Amphiroa rigida differ by more than 10 times.

Concentration of some elements in all samples in mg/kg:

Location	Type of marophytes	Na mg/kg	Mg mg/kg	Al mg/kg	S mg/kg	Cl mg/kg	K mg/kg	Ca mg/kg	Sc mg/kg	Ti mg/kg	V mg/kg	Mn mg/kg	Ni mg/kg	Co mg/kg
1 Agiba	Cladophora sp., 2016	8820 ± 353	6100± 305	973± 49	38300± 8874	73600± 5196	62800± 4396	207000± 39330	0.393± 0.01179	136± 30	5.12± 0.256	27.2± 2.2	3.09± 0.37	0.425± 0.03
2 El Obayed	Posidonia balls, 2016	8375± 335	5205± 208	826± 41	8050	11485± 812	2670± 294	87200± 16568	0.325± 0.01		2.06± 0.12	19.6± 1.6	2.52± 0.30	0.729± 0.051
	Sargassun sp., 2016	22000± 880	8250± 330	780± 39	13145± 2990	22450± 1586	18270± 1644	53050± 10079	0.2035± 0.0081		27.7± 1.1	25.6± 1.92	3.79± 0.40	0.9115± 0.0638
3 Cleopatra	Cystoseira sp., 2015	10500± 200	10200±200	83.2± 3.0	28700± 600	29500± 2200	46000± 3700	19000± 1300	0.030± 0.010		13.2± 0.5	5.4± 0.7	1.26± 0.19	0.19± 0.01
	Posidonia balls, 2015	16400± 300	5700± 150	431± 11	11.900± 4100	36400± 2700	1600± 900	14250± 1000	0.14± 0.2	40± 24	14± 0.1	11.3± 1.0	2.22± 0.18	0.27± 0.01
4 Romil	Cymodocea nodosa, 2016	23200± 984	7390± 338	329± 16.9	30150± 7069	56750± 4007	39950± 2830	33500± 6479	0.06495± 0.00547		5.97± 0.306	65.3± 4.65	4.815± 0.505	2.56± 0.16
	Cladophora sp., 2016	5050± 214	5620± 256	3980± 194	16500± 4701	6300± 445	7890± 438	95200± 18392	1.11± 0.0314	285± 29.2	59.9± 2.5	35.1± 2.51	3.31± 0.429	1.03± 0.0679
5 Citadel	Gelidium pusillum, 2015	30400± 600	9000± 200	72.7± 7	82600± 21200	58300± 4400	42300± 3900	5000± 400	0.010± 0.003	73± 37	3.7± 0.3	18.5± 1.4	2.31± 0.24	0.23± 0.01
6 Abo-Qir	Hypnea sp., 2015	81800	5680	157	125000	87100	23300	5830	0.0358	100	1.95	13.2	0.89	0.
	Ulva intestinalis, 2015	50000	28400	483	66500	118000	28200	8410	0.0925		3.56	24.5± 1	1.74± 0.21	0.22± 0.01
	Amphiroa, summer 2015	5420	41950	678	7030	7855	6190	246500	0.0997	110	3.695	48.6 ± 2.3	0.85± 0.13	0.28± 0.01
	Amphiroa winter 2015-2016	4915	27550	1409.5	11800	5755	6975	222000	0.43	400	4.47	108.8	1.55	0.71
	Amphiroa summer 2016	12820	12034.769	1340.882	21750.21008	24282.71008	19151.5126	80638.23529	0.581660714		15.618361	53.802101	3.47548319	1.33099789
	Entermorpha , 2016	13985	10286.071	1197	23953.57143	27211.07143	20955.7143	62190	0.607882143		16.172143	46.335714	3.73821429	1.40646428
Rasheed	Entermorpha sp.	3320	6550	2880	15500	1200	2620	8010	4.49	3630	30.3	186	7.38	4.6

Location	Type of marophytes	Fe mg/kg	Zn mg/kg	As mg/kg	Se mg/kg	Br mg/kg	Sr mg/kg	Rb mg/kg	Mo mg/kg	Ag mg/kg	Sb mg/kg	I mg/kg	Ba mg/kg	Cs mg/kg
1 Agiba	Cladophora sp., 2016	1160±58	9.97±0498	1.69±0.3	0.192±0.052	942±28	4300±387	14.3±2.43			0.162±0.01		15.9±2.0	0.0862±0.004
2 El Obayed	Posidonia balls, 2016	1115±56	7.72±0.46	4.18±0.19	0.6675±0.0601	287.5±8.6	1670±150	2.15±0.37		0.0312±0.009	0.7265±0.3632			0.1083±0.004
	Sargassun sp., 2016	583±35	38.4±1.6	25.1±0.8	1.17±0.09	1138.5±34.2	3015±271	5.77±0.98		0.026_0.006	0.142±0.009		32.9±3.9	0.0705±0.003
3 Cleopatra	Cystoseira sp., 2015	72±9	65.0±1.7	45.9±09	0.10±0.03	455±54	1505±93	16.9±3.1	1.48±0.94	0.010±0.003	0.090±0.010	140±21	29.5±2.00	0.020±0.002
	Posidonia balls, 2015	437±23	2.07±0.17	3.22±0.13	0.56±0.03	412±50	354±21	0.7±0.1	0.63±0.39	0.013±0.004	0.552±0.0164	819±120	2.42±0.28	0.020±0.002
4 Romil	Cymodocea nodosa, 2016	462.5±29.6	243±6.27	1.2125±0.133	0.263±0.046	446.5±14.78	617±55.2	9.605±1.600	2.65±0.826	0.0919±0.0087	0.208±0.017	138±49.45	6.03±0.934	0.0389±0.003
	Cladophora sp., 2016	3580±180	89.4±2.47	1,87±0.094	0.636±0.075	219±7.29	2360±211	8.58±1.43	0.802±0.254		0.631±0.0322	308±110.4	400±45.4	0.703±0.0233
5 Citadel	Gelidium pusillum, 2015	203±15	18.3±0.60	8.09±0.22	0.47±0.03	980±117	146±9	17.8±3.3		0.14±0.005	0.050±0.003	112±16	4.20±0.52	0.020±0.002
Abo-Qir	Hypnea sp., 2015	165±13	9.87±0.37	5.75±0.19	0.13±0.08	906±108	43±3	11.4±2.1		0.02±0.01	0.03±0.002	88±13	1.85±13	0.01±0.002
	Ulva intestinalis, 2015	533±32	11.8±0.4	8.58±0.45	0.19±0.03	890±106	11±7	8.5±1.6	1.04±0.49	0.01±0.002	0.03±0.002	41±6	5.04±0.63	0.03±0.002
	Amphiroa, summer 2015	292±18	19.7±0.6	2.09±0.06	0.11±0.04	200±24	2100±129	2.7±0.5	0.6±0.2	0.05±0.002	0.01±0.002	68±10	13.2±0.7	0.02±0.002
	Amphiroa winter 2015-2016	1022	40.2	3.64	0.12	223.5	1960	2.95	1.556	0.0356	0.11635	92.9	24.95	0.042
	Amphiroa summer 2016	1929.14496	68.393697	7.753203782	0.567823214	507.5105042	1696.534	6.247247899	#DIV/0!	0.067269048	0.278990336	284.45625	48.201364	0.1107266
	Entermorpha , 2016	2056.96429	74.592857	8.346964286	0.601425	551.1785714	1638.071	6.738214286		0.069166667	0.302335714	309.5	54.299091	0.1192035
Rasheed	Entermorpha sp.	15500	51.3	5.15		175	114	3.48	0.466	0.21	0.0839	42.3	34.6	0.1

Location	Type of marophytes	La mg/kg	Ce mg/kg	Sm mg/kg	Tb mg/kg	Tm mg/kg	Hf mg/kg	Ta mg/kg	Th mg/kg	U mg/kg
1 Agiba	Cladophora sp., 2016	1.92± 0.13	3.48± 0.45		0.0481± 0.002	0.0379± 0.0094	0.522± 0.157	0.038± 0.002	0.342± 0.014	1.84± 0.13
2 El Obayed	Posidonia balls, 2016	1.415± 0.071	2.245± 0.314	0.193± 0.041	0.03685± 0.00184	0.03125± 0.00687				
	Sargassun sp., 2016	1.58± 0.17	1.595± 0.295	0.0484± 0.0128	0.0211± 0.0013			0.0205± 0.0012	0.1755± 0.0070	1.095± 0.113
3 Cleopatra	Cystoseira sp., 2015	0.17± 0.06					0.04± 0.01	0.010± 0.002	0.20± 0.002	0.76± 0.05
	Posidonia balls, 2015	0.27± 0.13	4.13± 0.61	0.05± 0.02	0.014± 0.002			0.010± 0.002	0.080± 0.004	0.82± 0.05
4 Romil	Cymodocea nodosa, 2016	0.547± 0.0765			0.00624± 0.0012		0.123± 0.038	0.00987± 0.0088	0.0566± 0.0035	0.6685± 0.046
	Cladophora sp., 2016	3.62± 0.1577	5.28± 0.496	0.286± 0.0661	0.0803± 0.003	0.0533± 0.0116	1.24± 0.374	0.147± 0.0046	0.851± 0.0271	1.54± 0.084
5 Citadel	Gelidium pusillum, 2015							0.010± 0.002	0.010± 0.002	0.31± 0.10
6 Abo-Qir	Hypnea sp., 2015	0.13± 0.1		0.05± 0.03	0.002± 0.001			0.03± 0.001	0.01± 0.004	0.23+0.07
	Ulva intestinalis, 2015						0.05± 0.02	0.01± 0.002	0.03± 0.002	0.25± 0.06
	Amphiroa, summer 2015	0.37± 0.04	5.72± 0.04	0.09± 0.01			0.05± 0.01	0.01± 0.002	0.05± 0.004	0.28± 0.02
	Amphiroa winter 2015-2016	1.81	2.955	0.211	0.0461	0.0212	0.534	0.0396	0.5775	0.504
	Amphiroa summer 2016	2.354298319	#DIV/0!	#DIV/0!	0.047790546	#DIV/0!	2.32319481	0.094901222	0.905187981	1.004216346
	Entermorpha , 2016	2.545071429			0.050569286		2.64772727	0.105078333	1.014407692	1.088961538
Rasheed	Entermorpha sp.	17.7	29.6	2.42	0.343	0.142	24.9	0.805	10.5	2.83

`The data showed:

- for Ti, Ni, Co, Fe, Ag, Mn have their highest concentration in Entermorpha sp. from Rasheed.
- La, Ce, Sm, Tb, Tm, Hf, Ta, Th and U are rare earth elements have highest values in Entermorpha sp. from Rasheed.
- Highest value of V was 59.9 mg/kg in Cladophora sp.from Romil.
- Highest value of Zn was 243 mg/kg in Cymodocea nodosa collected from Romil .
- The highest content of As was 45 mg/kg and was found in Cystoseira sp. Collected from Cleopatra beach Marsa Matroh.

On comparing our results with other data reported for other location on the Mediterranean Sea it showed that:

1- The concentration of V in Cladophora sp. and Posidonia sp. from Marsa Matroh are relatively higher than corresponding data from Thessaloniki gulf in Greece reported in 2007.

2- And for Hypnea sp. and Ulva sp. from Alexandria it is found that the V are less by 5 times than the corresponding value from Thessaloniki gulf in Greece reflecting an accepted levels of V in Alexandria coastal areas.

- For Mn the concentrations measured for Cladophora sp., Cystoseira sp., Hypnea sp. and Ulva sp.collected from Alexandria and Marsa Matroh showed a much less value than reported in Greece reflecting an accepted levels of Mn in these areas.
- On comparing Mn from Rasheed with data from Greece it was found that Mn concentration is higher reflection a higher levels of Mn in this area.

- For Fe the concentrations measured for Posidonia sp. from Marsa Matroh showed a higher value than reported in the same area in 2010. reflecting an increase of Fe emission to the environment is this area.
- In the same way in Alexandria measurements for Enermorpha sp. and Ulva sp. it was found that the Fe content are much higher than corresponding data reported in 2008-2010.

- Data obtained for Co in most studied locations and species(Cladophra sp., Cystoseira sp., Hypnea sp., Ulva sp. Corallinalis sp. and Entermorpha sp.) showed a lower value than corresponding data in different locations around the Mediterranean Sea reflecting an accepted levels of Co in all studied locations.

- For Ni content in Cladophra sp., Posidonia sp., Cystoseira sp. Cymodocea sp., Hypnea sp., Ulva sp. Corallinalis sp. and Entermorpha sp. are relatively lower than corresponding reported data from Alexandria, Marsa Matroh and Thesssaloniki gulf in Greece.

- With respect to Zn, of Cystoseira sp.from Marsa Matroh our result is two times the data reported in Marsa Matroh in 2009-2010 and about three times data reported from Tartous, Syrian coast, while still lower than data reported from Thessaloniki gulf, Greece.
- significant findings is that for Cymodocea sp. showed Zn content are found to be four times than corresponding reported data from Marsa Matrouh in 2009-2010 indicates that an increase in Zn emission to the environment in this area.
- Entermorpha sp. from Alexandria and Rasheed show a relatively high content of Zn compared with other data reflecting also a higher content of Zn in these locations

- All this can reflect an increase of Zn emission to the environment which due to corrosion of Zn based alloys which is widely used in ship building.

Correlation analysis:

Data was analyzed to utilize correlation analysis using Person rank order correlation using SPSS.

- A positive correlation between (As, Cd, Sr, Th, U and rare earth element) forming a group which may be coming from fertilizers.
- The second group having correlation is group from (Al, Sc, Fe, Rb, Cs, Th, U) which have terrigenous origin.
- A positive significant correlation between (Ti, Mn, Ni, Co, Fe, Ag, Th) may be reflected due to chemical peculiarities of igneous rocks.

Conclusion:

-Neutron activation analysis was used to determine the concentrations of over 30 elements, including Mn, Fe, Co, Ni, and Zn, in marine macrophytes along the Egyptian coast of the Mediterranean Sea.

- Concentrations varied widely depending on the species of macrophyte analyzed

.- The concentrations of Co, Ni, Se, Mo, Ag, Cs, La, Sm, Yb, Hf, Ta, and U were very similar in all samples.

.- Results showed that V content in Marsa Matrouh samples was higher than compared data, while in Alexandria it was lower than compared data.

- Mn, Ni, and Co contents were within accepted levels in all compared data, except for Mn content in samples from Rasheed area.

-The content of Zn varied according to type of macrophytes and location of sampling, samples from Marsa Matroh showed a higher content than compared data reflecting a main pollution problem appearing in Marsa Matroh.

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THANKS!

Do you have any questions?

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