The Elemental Content Of Seawater And Algae Collected From The Red Sea, The Arabian Gulf, And The Gulf Of Oman: Preliminary Study

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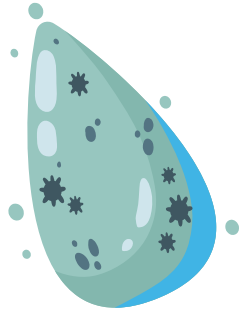
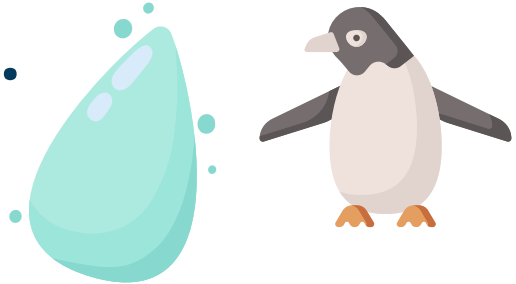




1

Aim of this work

01

Assess elemental content including heavy metals in both water and algae samples from Red sea, Arabian Gulf and Gulf of Oman.

02

Comparison between elemental content in water samples from The Red Sea , Arabian Gluf and the Gulf of Oman

03

Comparison between elemental content in algae samples from The Red Sea, Arabian Gulf, and the Gulf of Oman

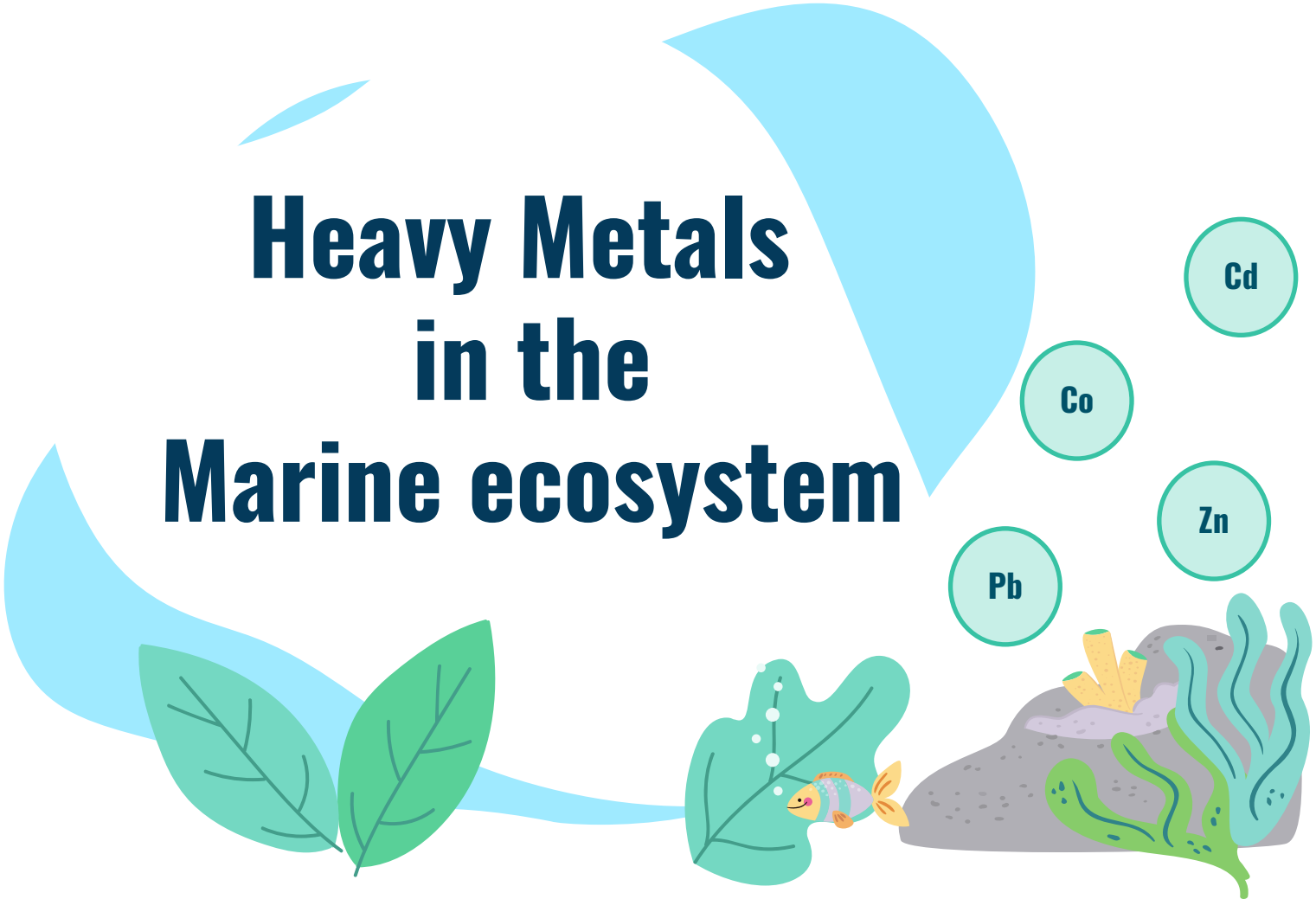
04

Calculate the Enrichment factor for each element in different types of algae

2

Introduction

Heavy Metals in the Marine ecosystem



Heavy Metals in The Marine Environment

Study Area

The Red Sea coast

Tourism Activites

Shipping activities near Suez Harbor

The Red has a very unique location and is considered one of the main Marine Navigation paths connecting the Indian Ocean to the Mediterranean Sea through the Suez Canal.

Despite its important location, The Red Sea has fast-growing anthropogenic activities ranging from Oil Mining, pathing through cement and pesticide industries, and ending with tourist activities.

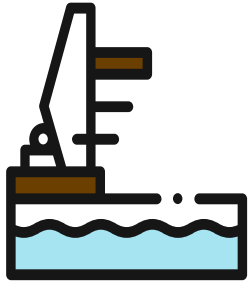
Oil Mining Activities

Phosphate contamination

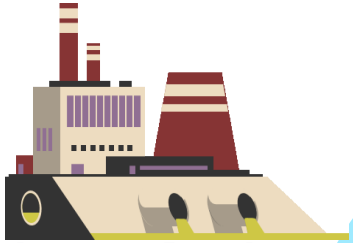
The Arabian Gulf region

The large extent of Oil spill

The Arabian Gulf is an extension of the Indian Ocean located in the southwest of Asia between the Islamic Republic of Iran and the Arabian Peninsula. Due to the rapid development in this region, the water resources are subjected to potential pressure and facing numerous environmental challenges. desalination plants



Shipping activities



Industrial Discharge

Coastal development

Desalination plants

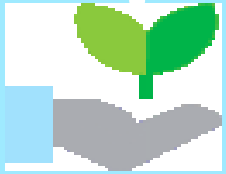
Gulf war in 1991

3

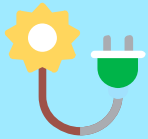
Experimental work

Experimental work

Sampling Locations



Sampling collection



Sampling preparation and analysis

Sampling Locations:

24 algae samples and 9 samples of water were collected from 5 stations in the Red Sea, 2 stations in the Gulf of Oman, and 2 stations in the Arabian Gulf.

1: Kalba. 2: Dibba Fujairah.
3: Ras Al Khaima. 4: Dhanna Abu Dhabi.

1: Safaga. 2: Hurghada. 3: Ras Gharib.
4: Zaafrana. 5: Ain Soukhna

Sampling Collection and Preparation

Sampling Collection

All Algae samples were collected by hand at a depth of 1.5m, and all water samples were collected at a depth of 1.5 -2 meters.

Sampling preparation

All algae samples were washed from epiphytes with ambient water and transferred to the lab in an ice box. In the lab, all algae samples were washed with distilled water and dried till constant weight at 105 °C, then homogenized in a gate mortar. All water samples were treated with conc. Nitric acid and kept in a high-density polyethylene bottle at -10 °C till analysis.

Samples measurements

The elemental analysis was determined using ICP-OES Plasma Quant 9000 Elite (Analytik Jena, Germany), Frank Lab of Neutron Physics, JINR.

Samples prepration

0.5 grams of algae were placed into Teflon vessels and subjected to digestion using 5 mL of high-purity HNO_3 and 2 mL H_2O_2.

Samples digestion

Samples were digested at 180°C in the Mars 6 microwave digestion system (CEM, USA). After cooling the digested samples were fully transferred into 50-milliliter flasks and diluted to volume with deionized water.

Quality Control

The analysis of reference material maintained the assurance of measurement quality, five certified reference materials were used to perform this analysis.

Atomization

Samples were pumped inside the sprayer and then flamed to turn into plasma.

Samples measurments

Each sample is measured separately, followed by 2% Nitric acid washing.

Detection

All detected spectrum is obtained and the concentration of each element is determined.

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Results and Outcomes

The concentrations of Na, Mg, Al, Ca, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Sr, Cd, Ba, and Pb for all algae types were determined, while the concentrations of Cr, Co, Ni, C, Pb and Cd were below the limits of detection in water samples.

Water samples

Elements concentration in water samples mg/L :

Station Name	Na mg/L	Mg mg/L	Al mg/L	Ca mg/L	V mg/L	Mn mg/L	Fe mg/L	Zn mg/L	Sr mg/L	Ba mg/L
Safaga	24658.31	1866.08	0.0392	503.68	1.9279	0.0012	0.0104	0.0051	7.68	0.0090
Hurghada	23939.81	1818.08	0.0410	495.82	1.9727	0.0012	0.0116	0.0026	7.32	0.0093
Gharib	24250.59	1870.06	0.0513	479.58	1.8950	0.0019	0.0313	0.0035	7.22	0.0113
Zaafrana	20063.71	1562.47	0.0616	435.51	1.7768	0.0063	0.0519	0.0034	6.53	0.0107
Sukhna	22898.55	1834.57	0.1116	556.60	1.9179	0.0206	0.1484	0.0037	8.39	0.0121
Kalba	20340.04	1650.24	0.0286	439.09	1.7601	0.0009	0.0029	0.0026	6.86	0.0172
Diba Hisin	16723.56	1330.35	0.0254	358.85	1.4747	0.0007	0.0058	0.0019	5.32	0.0059
Rak	18902.95	1476.64	0.0269	407.42	1.6471	0.0003	0.0010	0.0013	6.25	0.0079
Danna Abu Dhabi	22283.77	1737.44	0.0409	482.73	1.8309	0.0003	0.0090	0.0012	7.28	0.0120

Heavy element content in all water samples:

Sr mg/L

V mg/L

Mn mg/L

Fe mg/L

Zn mg/L

Al mg/L

Ba mg/L

Safaga Hurghada Gharib Zaafrana Sukhna Kalba Diba Hisin Rak Danna Abu Dhabi

Algae Samples

Algae samples from The Red Sea:

Safaga *Turbinaria decurrens*
Safaga *Cystosiera myrica*
Hurghada *Turbinaria decurrens*
Hurghada *Saurgassum critaefolium*
Ras Gharib *Sargassum muticum*
Ras Gharib *Corallinalis*
Zaafrana *Sargassum vulgare*
Zaafrana *Sargassum latifolium*
Ain Soukhna *Sargassum Vulgare*

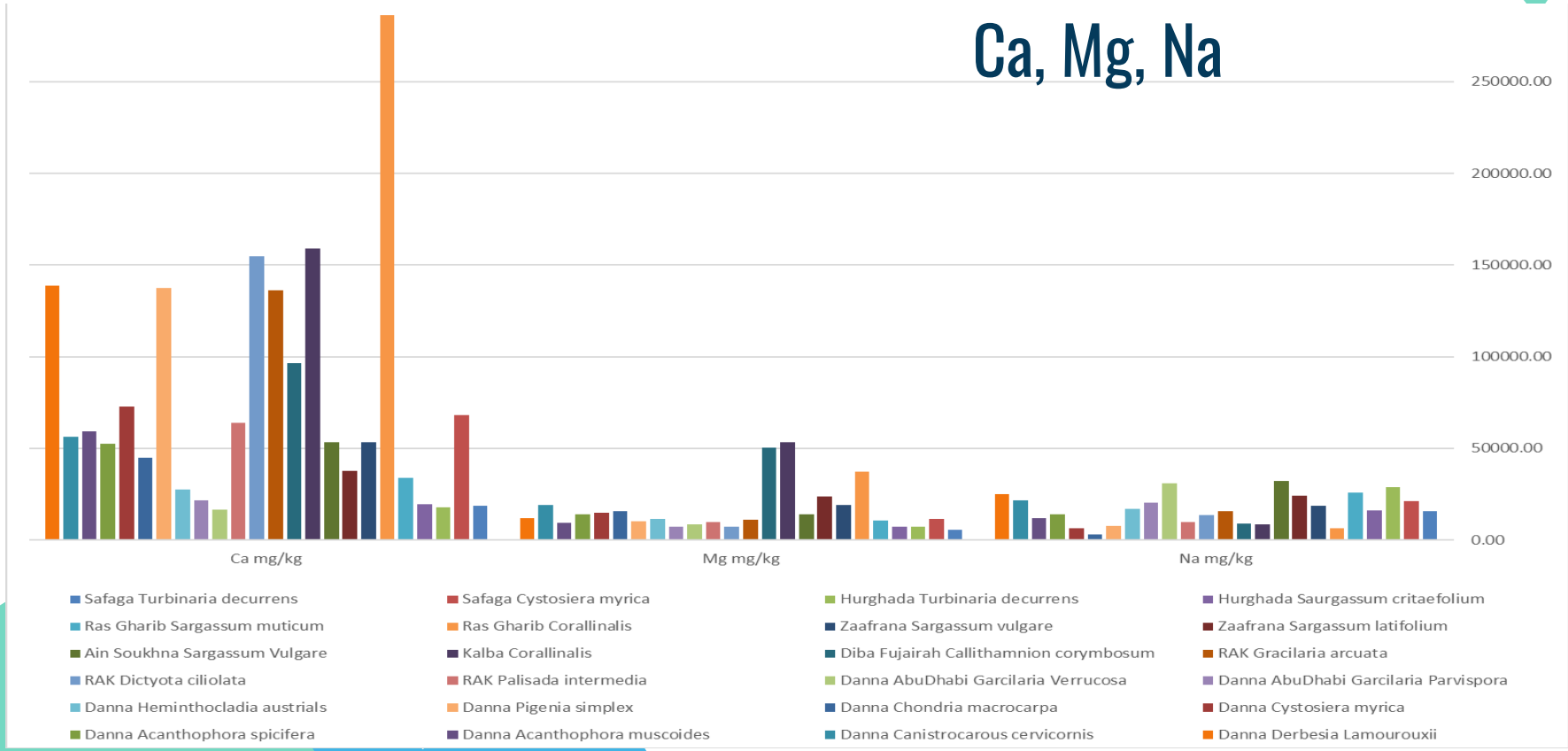
Algae Samples from the Gulf of Oman

Kalba *Corallinalis*
Diba Fujairah *Callithamnion corymbosum*

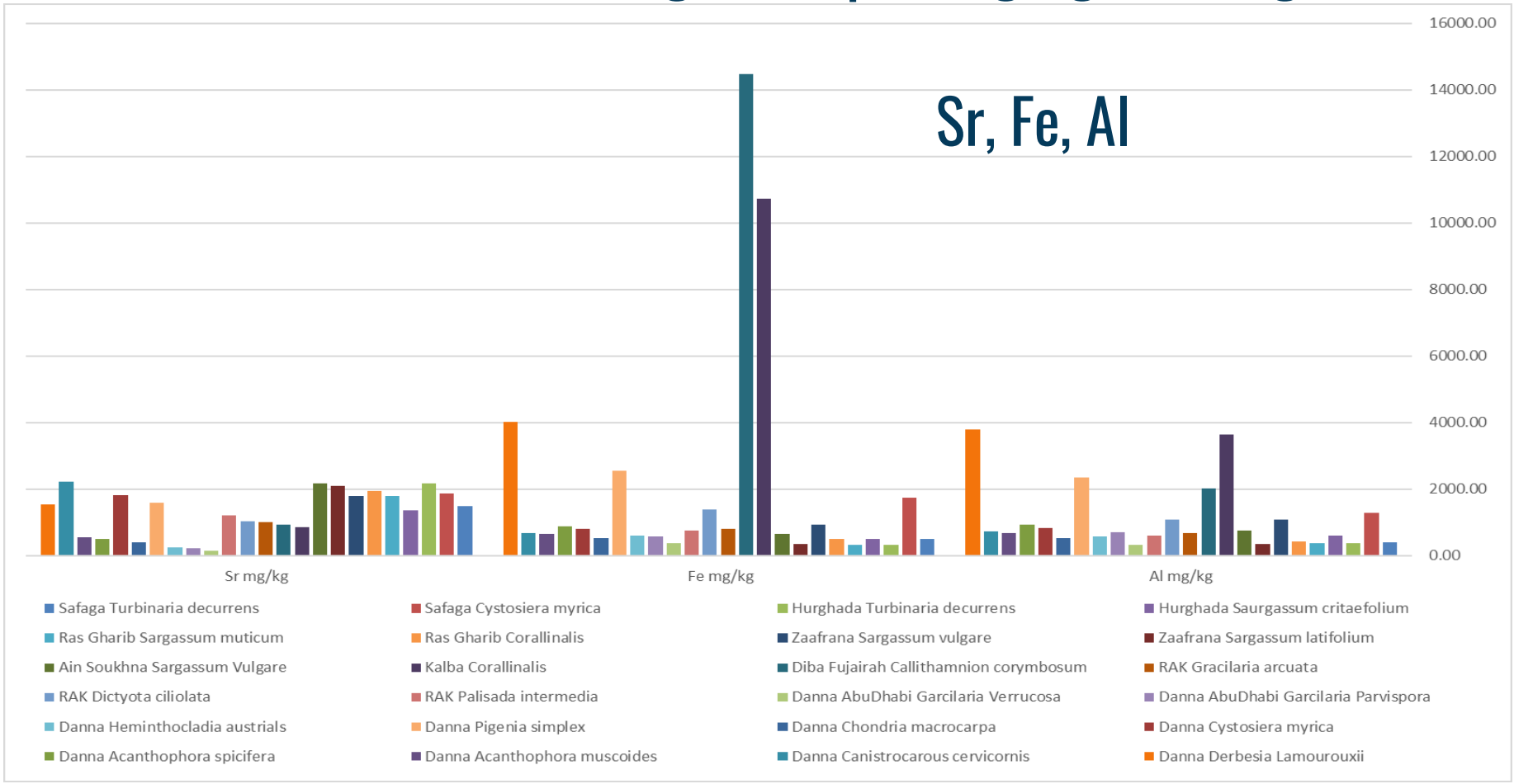
Algae Samples from the Arabian Gulf

RAK *Gracilaria arcuata*
RAK *Dictyota ciliolata*
RAK *Palisada intermedia*
Danna AbuDhabi *Garcilaria Verrucosa*
Danna AbuDhabi *Garcilaria Parvispora*
Danna *Heminthocladia austrials*
Danna *Pigenia simplex*
Danna *Chondria macrocarpa*
Danna *Cystosiera myrica*
Danna *Acanthophora spicifera*
Danna *Acanthophora muscoides*
Danna *Canistrocarous cervicornis*
Danna *Derbesia Lamourouxi*

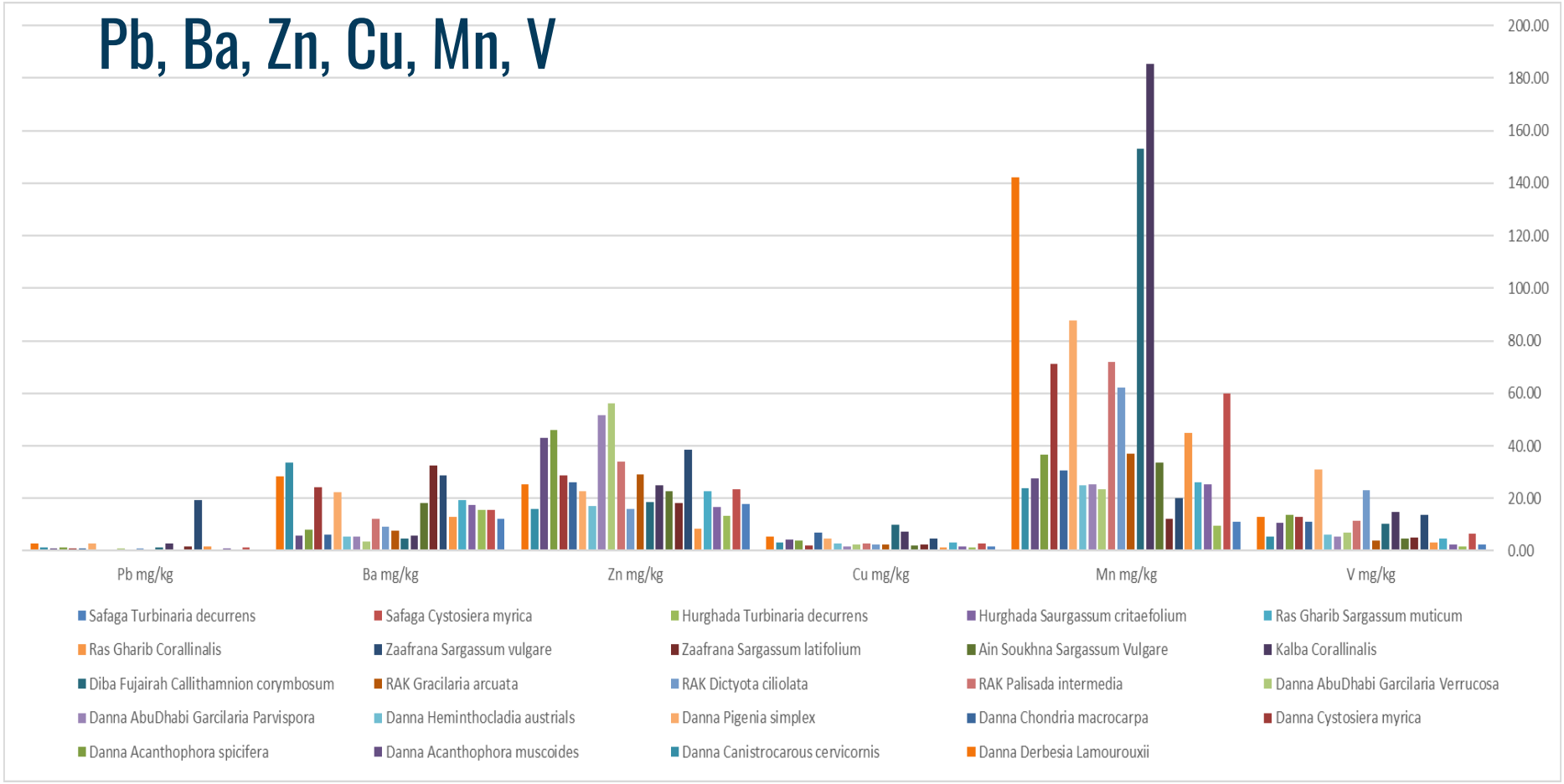
Elements concentration in algae samples mg/kg dry weight:



Elements concentration in algae samples mg/kg dry weight:

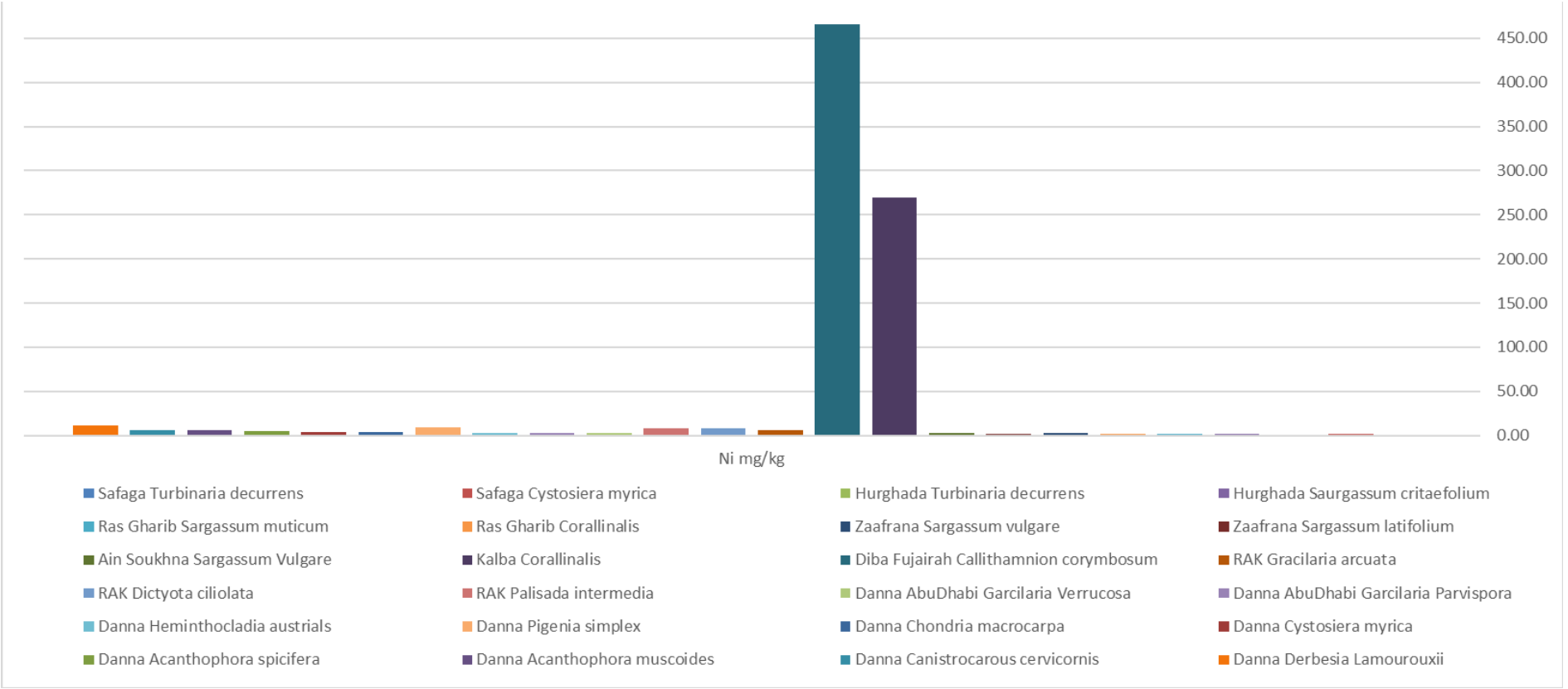


Elements concentration in algae samples mg/kg dry weight:



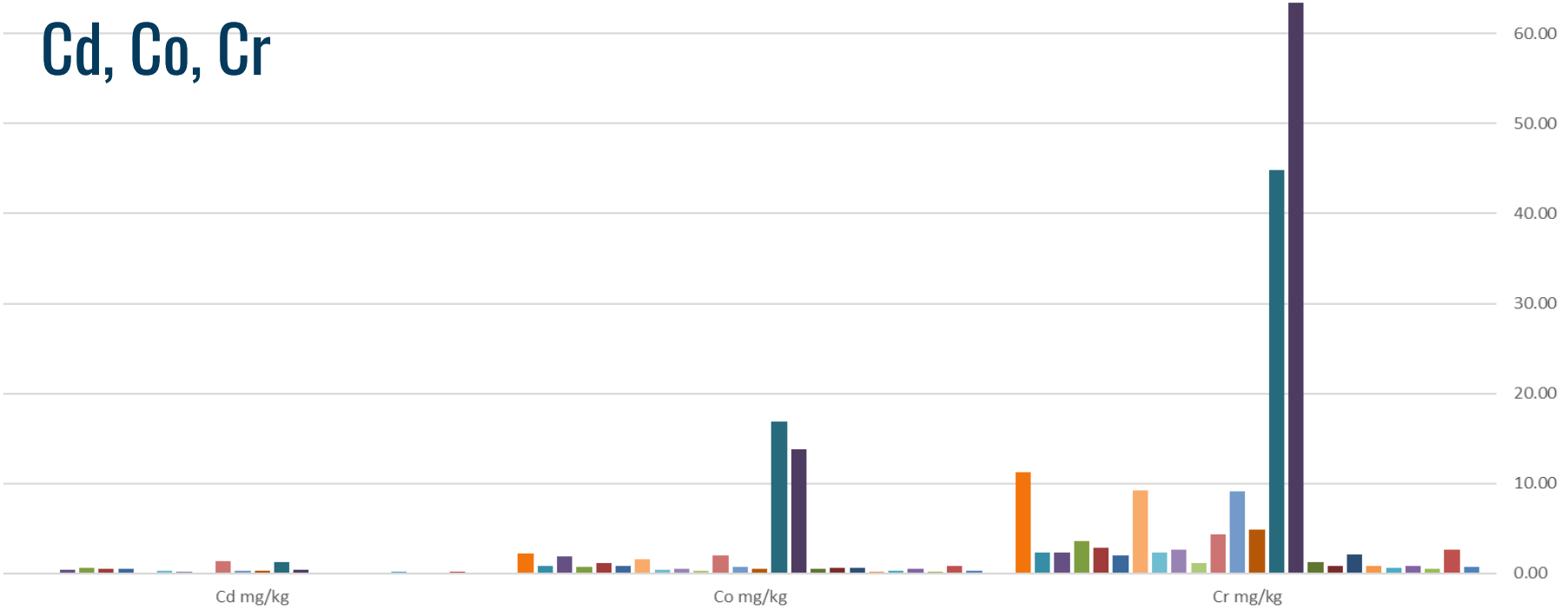
Elements concentration in algae samples mg/kg dry weight:

Ni



Elements concentration in algae samples mg/kg dry weight:

Cd, Co, Cr



The highest content of most elements (Mg, Cr, Mn, Fe, Co, Ni, and Cu) were found in Algae samples collected from the Gulf of Oman.

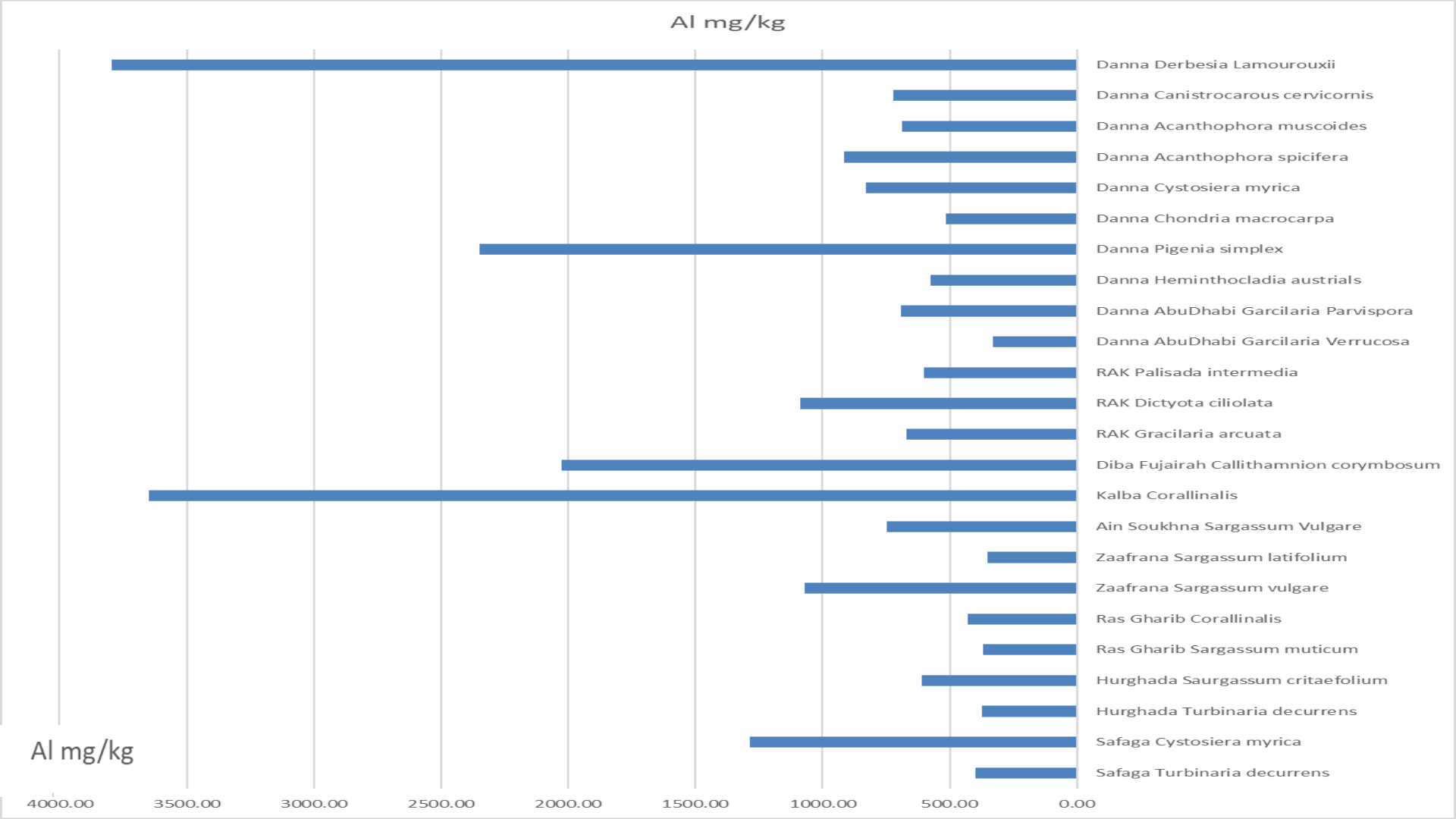
Callithamnion corymbosum

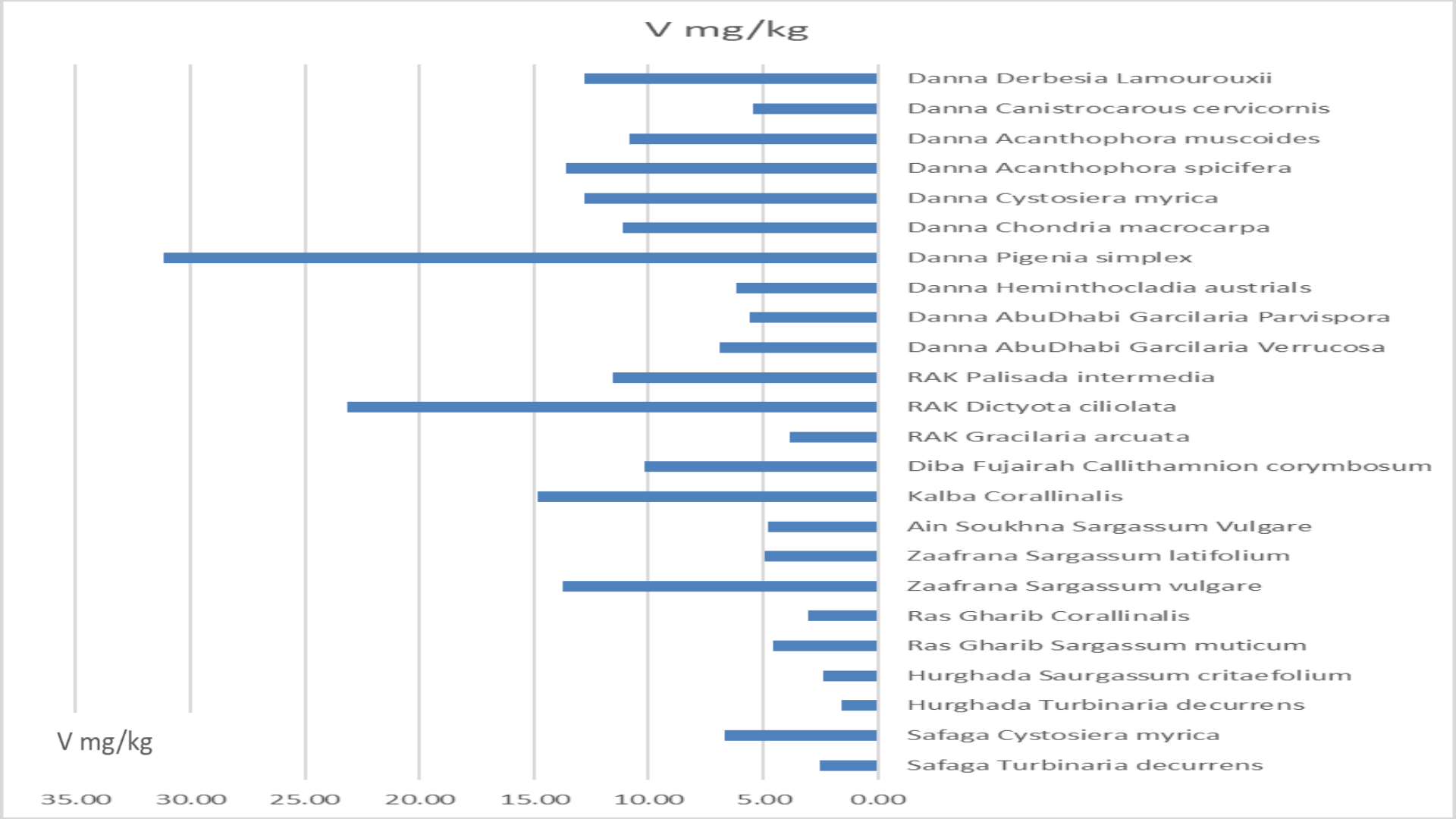
Corallinalis

The lowest concentration of most of the elements (V, Cr, Mn, Fe, Ni and Pb) were found in algae samples collected from Hurghada station on the Red Sea.

Turbinaria decurrens

The following charts will discuss the concentration of each element in different types of algae samples


Al mg/kg
Danna Derbesia Lamourouxii
Danna Canistrocarous cervicornis
Danna Acanthophora muscoides
Danna Acanthophora spicifera
Danna Cystosiera myrica
Danna Chondria macrocarpa
Danna Pigenia simplex
Danna Heminthocladia austrials
Danna AbuDhabi Garcilaria Parvispora
Danna AbuDhabi Garcilaria Verrucosa
RAK Palisada intermedia
RAK Dictyota ciliolata
RAK Gracilaria arcuata
Diba Fujairah Callithamnion corymbosum
Kalba Corallinalis
Ain Soukhna Sargassum Vulgare
Zaafrana Sargassum latifolium
Zaafrana Sargassum vulgare
Ras Gharib Corallinalis
Ras Gharib Sargassum muticum
Hurghada Saurgassum critaefolium
Hurghada Turbinaria decurrens
Safaga Cystosiera myrica
Safaga Turbinaria decurrens
Al mg/kg
4000.00
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00


V mg/kg
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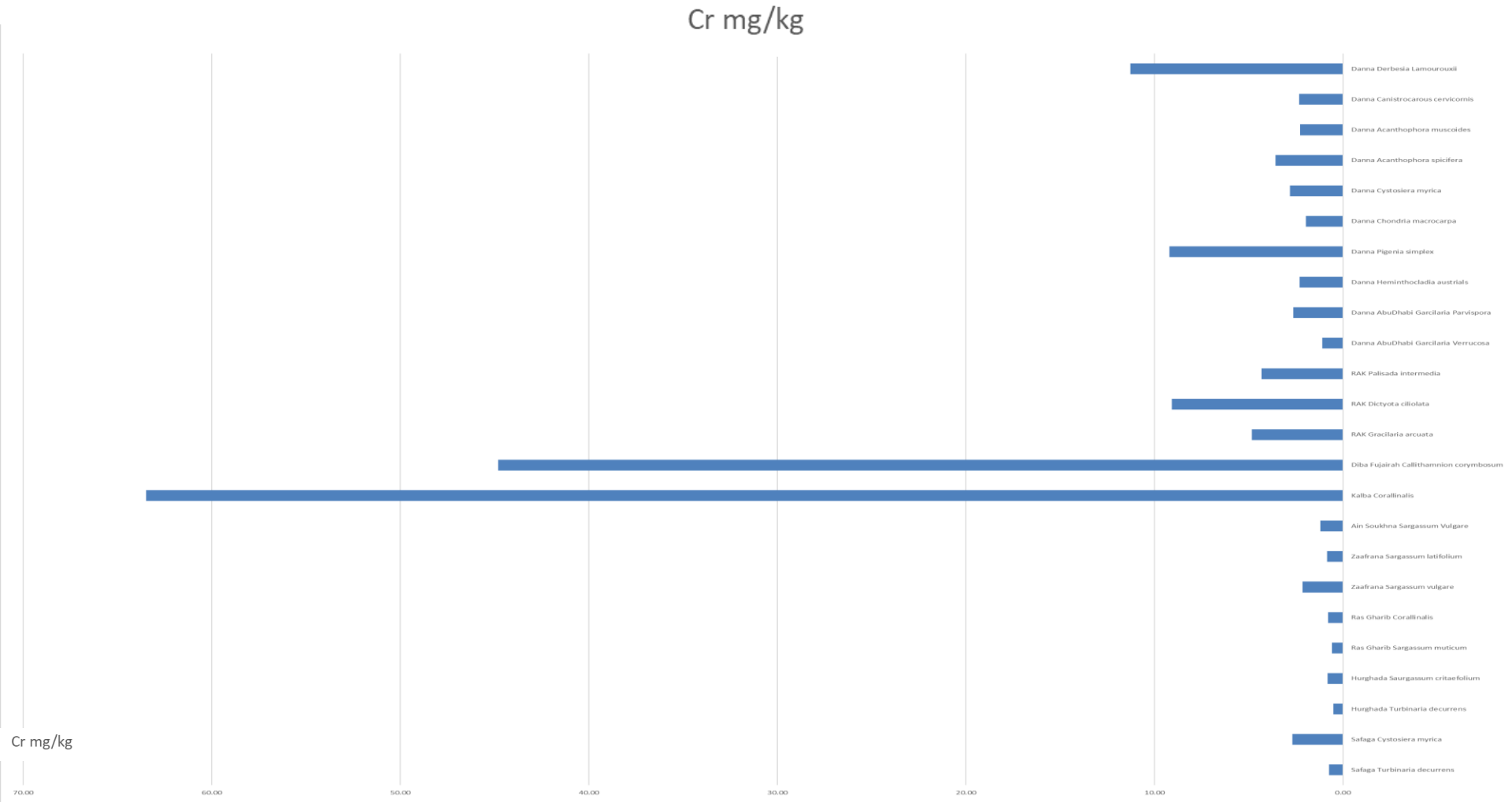
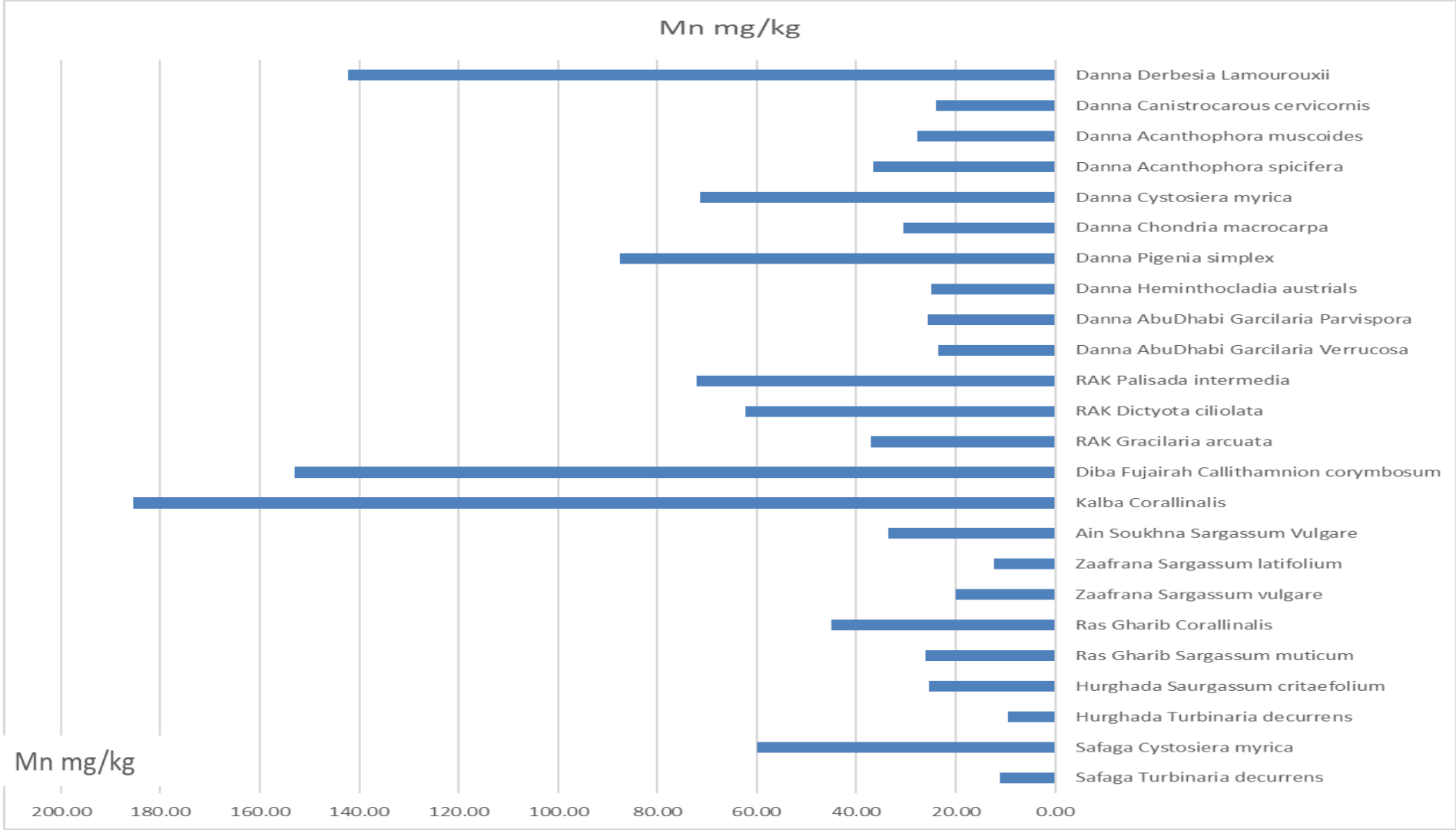
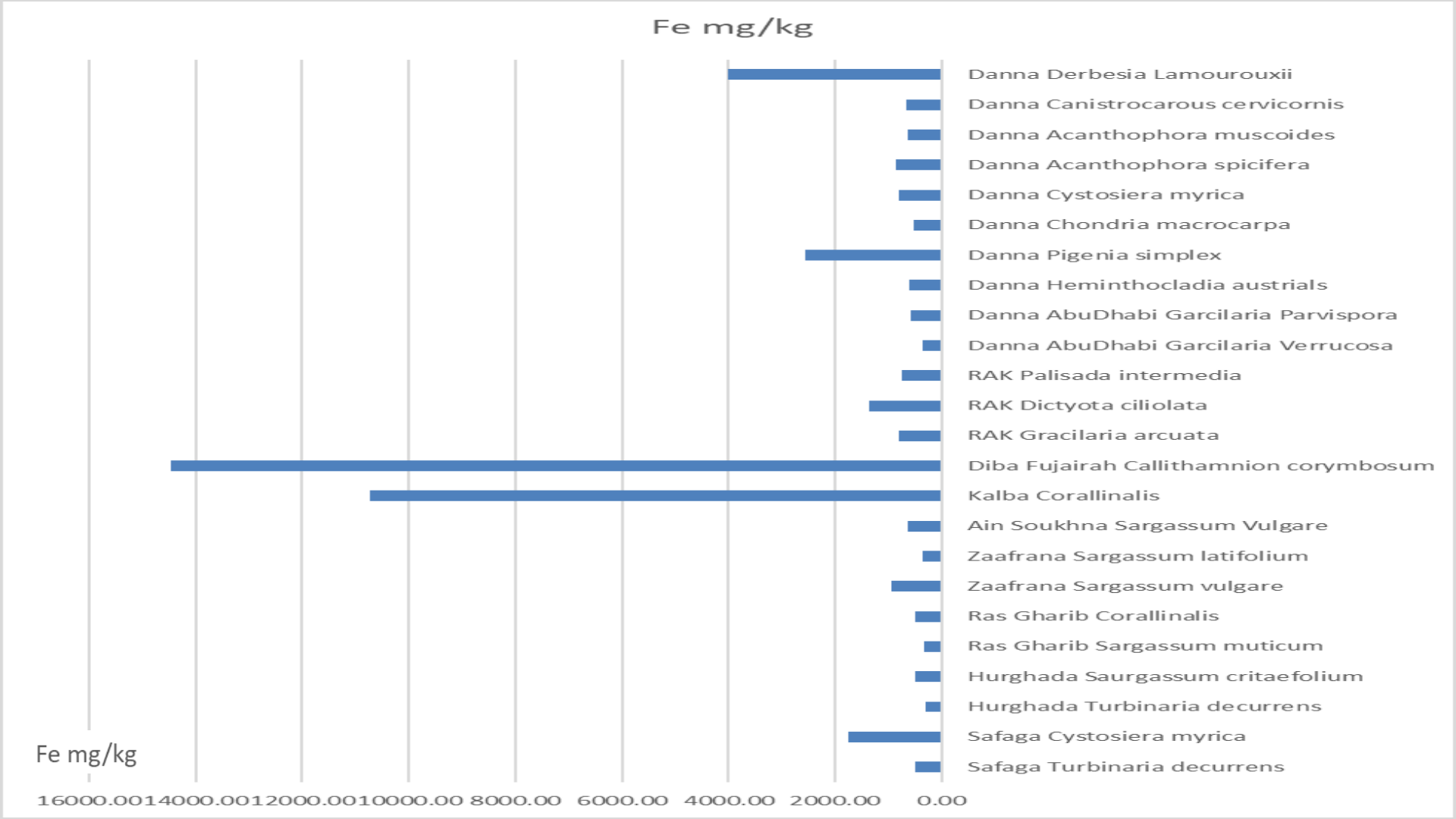
Danna Canistrocarous cervicornis
Danna Acanthophora muscoides
Danna Acanthophora spicifera
Danna Cystosiera myrica
Danna Chondria macrocarpa
Danna Pigenia simplex
Danna Heminthocladia austrials
Danna AbuDhabi Garcilaria Parvispora
Danna AbuDhabi Garcilaria Verrucosa
RAK Palisada intermedia
RAK Dictyota ciliolata
RAK Gracilaria arcuata
Diba Fujairah Callithamnion corymbosum
Kalba Corallinalis
Ain Soukhna Sargassum Vulgare
Zaafrana Sargassum latifolium
Zaafrana Sargassum vulgare
Ras Gharib Corallinalis
Ras Gharib Sargassum muticum
Hurghada Saurgassum critaefolium
Hurghada Turbinaria decurrens
Safaga Cystosiera myrica
Safaga Turbinaria decurrens
V mg/kg
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00


Cr mg/kg
Danna Derbesia Lamourouxii
Danna Canistrocarous cervicornis
Danna Acanthophora muscoides
Danna Acanthophora spicifera
Danna Cystosiera myrica
Danna Chondria macrocarpa
Danna Pigenia simplex
Danna Heminthocladia austrials
Danna AbuDhabi Garcilaria Parvispora
Danna AbuDhabi Garcilaria Verrucosa
RAK Palisada intermedia
RAK Dictyota ciliolata
RAK Gracilaria arcuata
Diba Fujairah Callithamnion corymbosum
Kalba Corallinalis
Ain Soukhna Sargassum Vulgare
Zaafrana Sargassum latifolium
Zaafrana Sargassum vulgare
Ras Gharib Corallinalis
Ras Gharib Sargassum muticum
Hurghada Saurgassum critaefolium
Hurghada Turbinaria decurrens
Safaga Cystosiera myrica
Safaga Turbinaria decurrens
Cr mg/kg
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00


Mn mg/kg
Danna Derbesia Lamourouxii
Danna Canistrocarous cervicornis
Danna Acanthophora muscoides
Danna Acanthophora spicifera
Danna Cystosiera myrica
Danna Chondria macrocarpa
Danna Pigenia simplex
Danna Heminthocladia austrials
Danna AbuDhabi Garcilaria Parvispora
Danna AbuDhabi Garcilaria Verrucosa
RAK Palisada intermedia
RAK Dictyota ciliolata
RAK Gracilaria arcuata
Diba Fujairah Callithamnion corymbosum
Kalba Corallinalis
Ain Soukhna Sargassum Vulgare
Zaafrana Sargassum latifolium
Zaafrana Sargassum vulgare
Ras Gharib Corallinalis
Ras Gharib Sargassum muticum
Hurghada Saurgassum critaefolium
Hurghada Turbinaria decurrens
Safaga Cystosiera myrica
Safaga Turbinaria decurrens
Mn mg/kg
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00


Fe mg/kg
Danna Derbesia Lamourouxii
Danna Canistrocarous cervicornis
Danna Acanthophora muscoides
Danna Acanthophora spicifera
Danna Cystosiera myrica
Danna Chondria macrocarpa
Danna Pigenia simplex
Danna Heminthocladia austrials
Danna AbuDhabi Garcilaria Parvispora
Danna AbuDhabi Garcilaria Verrucosa
RAK Palisada intermedia
RAK Dictyota ciliolata
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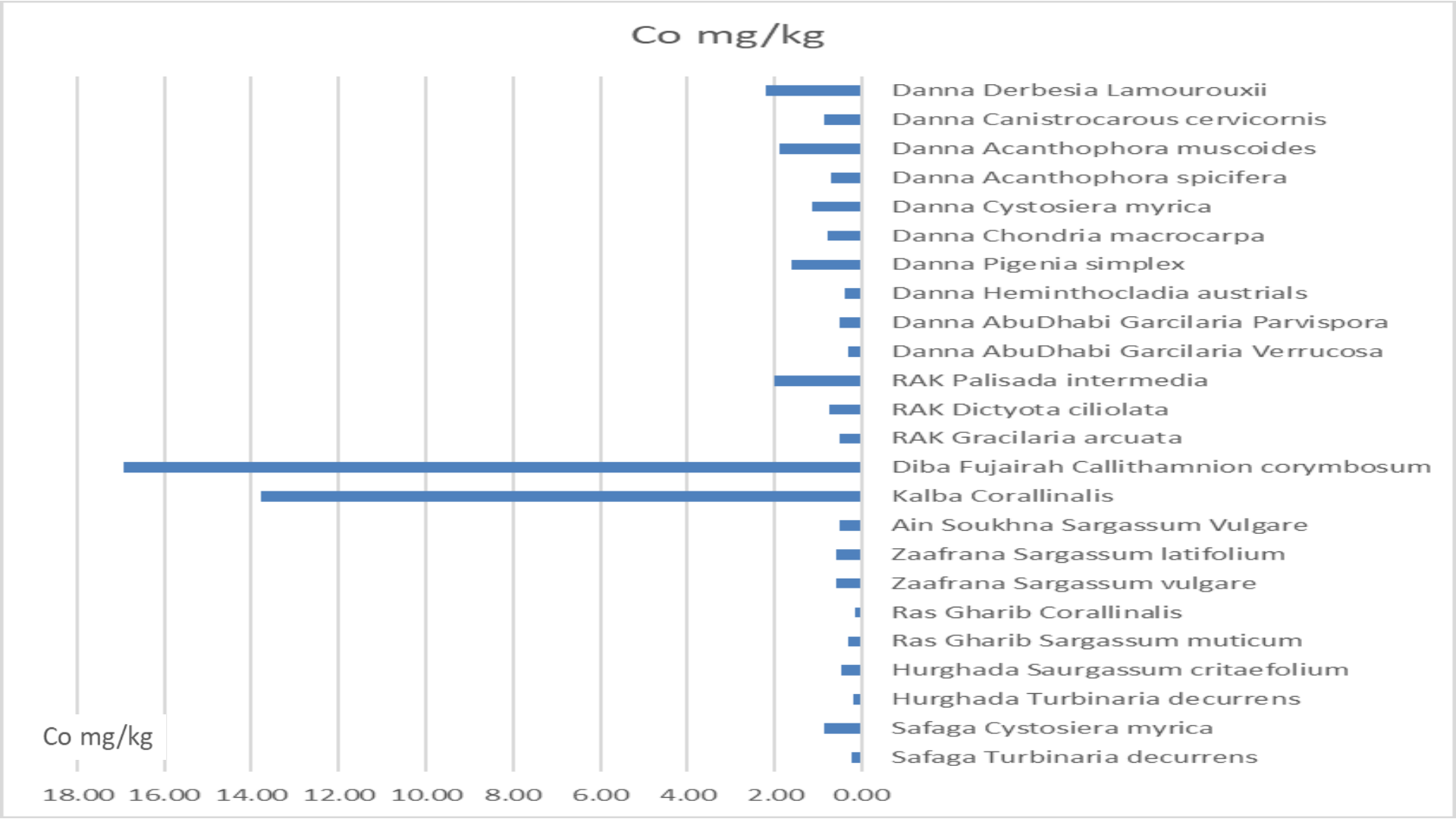
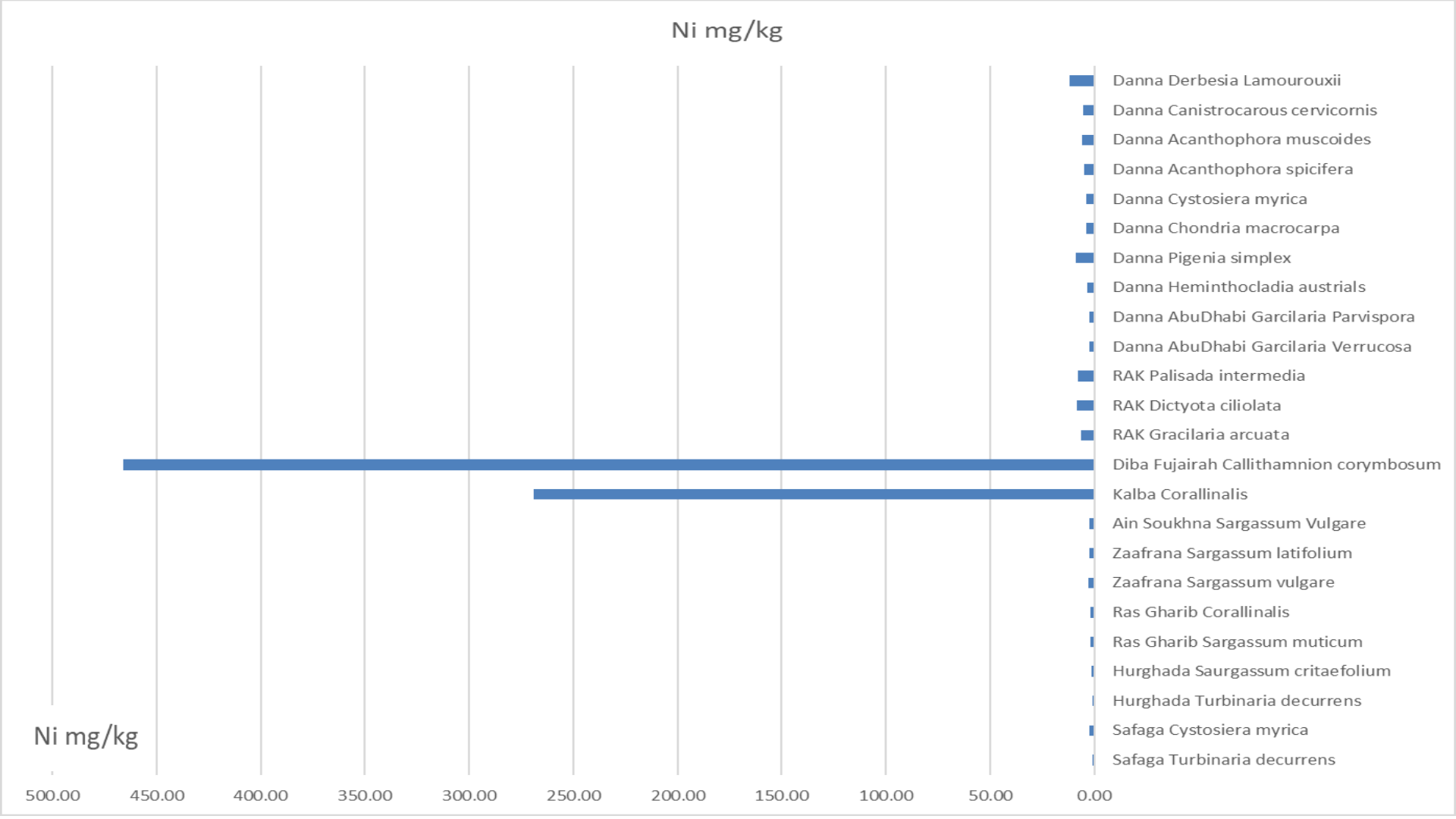
Zaafrana Sargassum vulgare
Ras Gharib Corallinalis
Ras Gharib Sargassum muticum
Hurghada Saurgassum critaefolium
Hurghada Turbinaria decurrens
Safaga Cystosiera myrica
Safaga Turbinaria decurrens
Fe mg/kg
16000.00 14000.00 12000.00 10000.00 8000.00 6000.00 4000.00 2000.00 0.00


Co mg/kg
Danna Derbesia Lamourouxii
Danna Canistrocarous cervicornis
Danna Acanthophora muscoides
Danna Acanthophora spicifera
Danna Cystosiera myrica
Danna Chondria macrocarpa
Danna Pigenia simplex
Danna Heminthocladia austrials
Danna AbuDhabi Garcilaria Parvispora
Danna AbuDhabi Garcilaria Verrucosa
RAK Palisada intermedia
RAK Dictyota ciliolata
RAK Gracilaria arcuata
Diba Fujairah Callithamnion corymbosum
Kalba Corallinalis
Ain Soukhna Sargassum Vulgare
Zaafrana Sargassum latifolium
Zaafrana Sargassum vulgare
Ras Gharib Corallinalis
Ras Gharib Sargassum muticum
Hurghada Saurgassum critaefolium
Hurghada Turbinaria decurrens
Safaga Cystosiera myrica
Safaga Turbinaria decurrens
Co mg/kg
18.00 16.00 14.00 12.00 10.00 8.00 6.00 4.00 2.00 0.00


Ni mg/kg
Danna Derbesia Lamourouxii
Danna Canistrocarous cervicornis
Danna Acanthophora muscoides
Danna Acanthophora spicifera
Danna Cystosiera myrica
Danna Chondria macrocarpa
Danna Pigenia simplex
Danna Heminthocladia austrials
Danna AbuDhabi Garcilaria Parvispora
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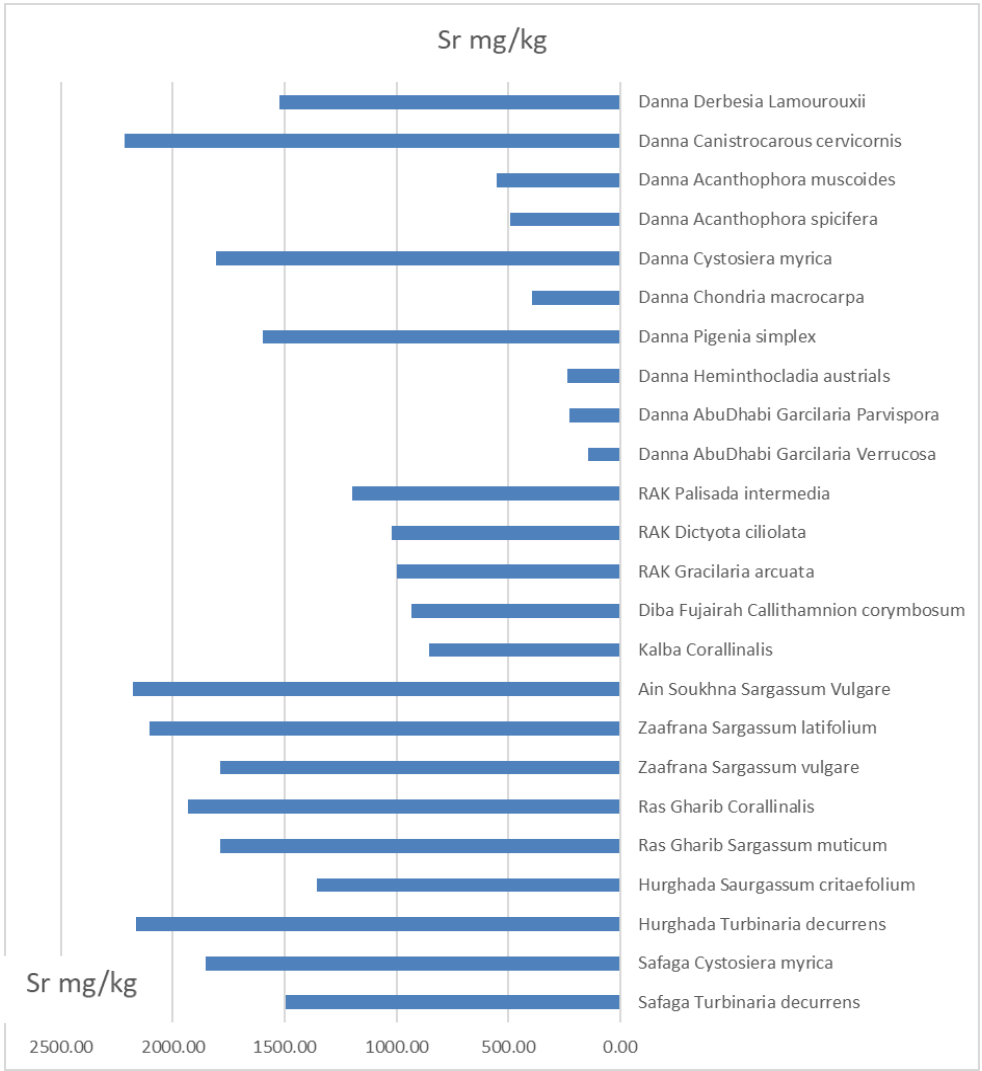
Ras Gharib Corallinalis
Ras Gharib Sargassum muticum
Hurghada Saurgassum critaefolium
Hurghada Turbinaria decurrens
Safaga Cystosiera myrica
Safaga Turbinaria decurrens
Ni mg/kg
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00


Sr mg/kg
Danna Derbesia Lamourouxii
Danna Canistrocarous cervicornis
Danna Acanthophora muscoides
Danna Acanthophora spicifera
Danna Cystosiera myrica
Danna Chondria macrocarpa
Danna Pigenia simplex
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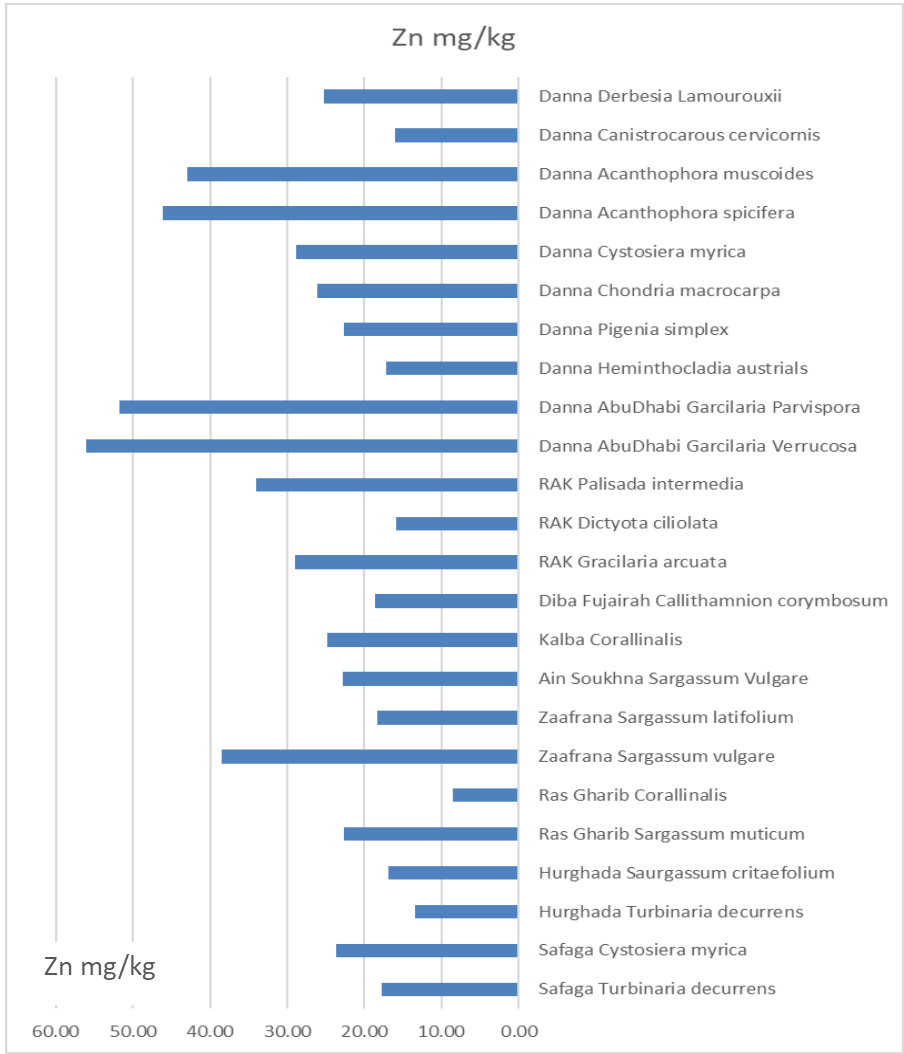
Ras Gharib Sargassum muticum
Hurghada Saurgassum critaefolium
Hurghada Turbinaria decurrens
Safaga Cystosiera myrica
Safaga Turbinaria decurrens
Sr mg/kg
2500.00
2000.00
1500.00
1000.00
500.00
0.00


Zn mg/kg
Danna Derbesia Lamourouxii
Danna Canistrocarous cervicornis
Danna Acanthophora muscoides
Danna Acanthophora spicifera
Danna Cystosiera myrica
Danna Chondria macrocarpa
Danna Pigenia simplex
Danna Heminthocladia austrials
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Danna AbuDhabi Garcilaria Verrucosa
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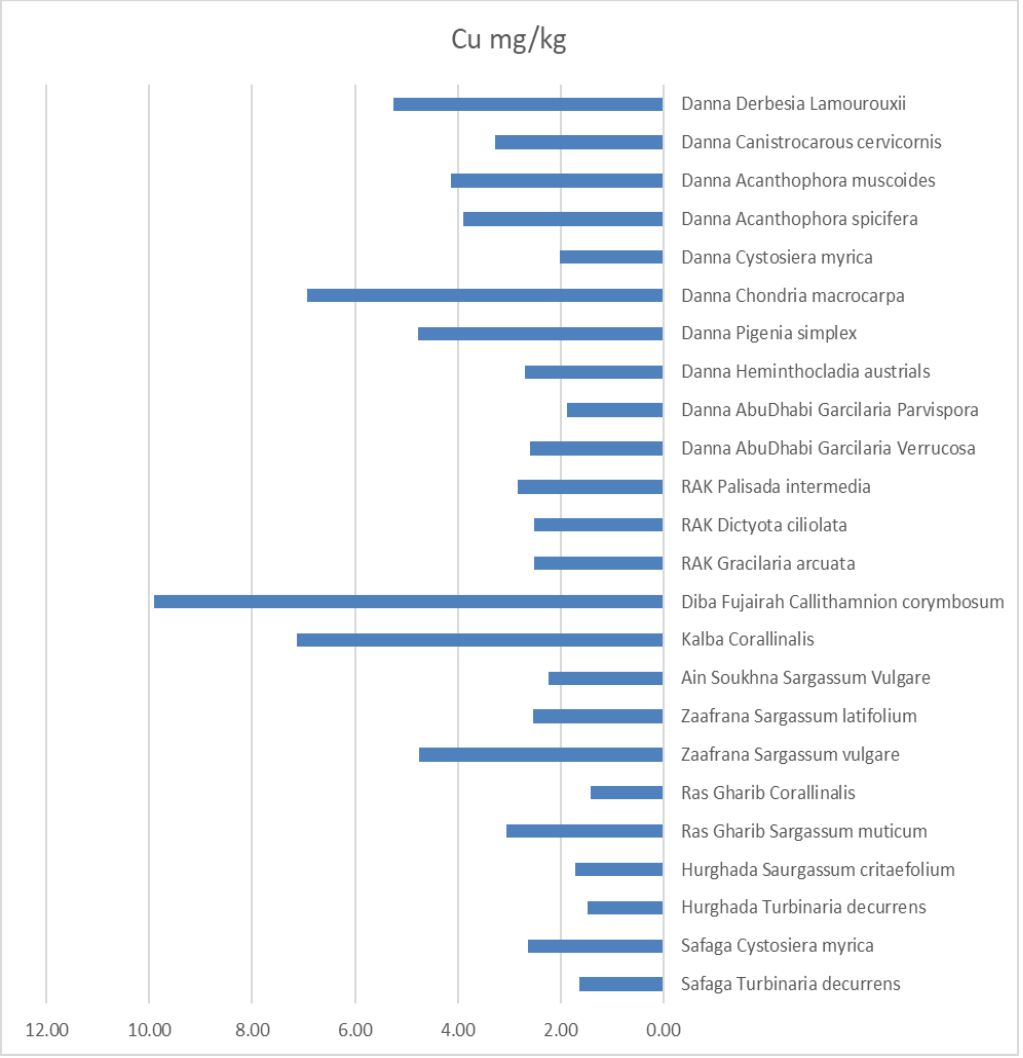
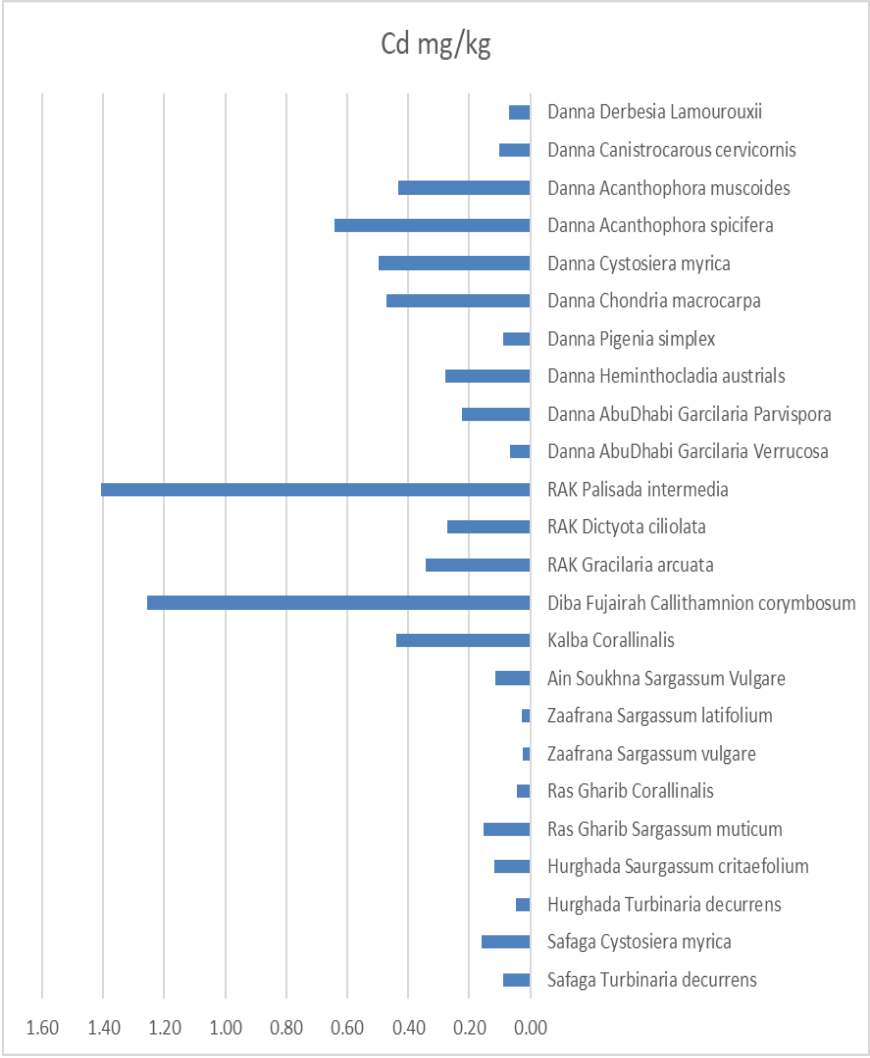
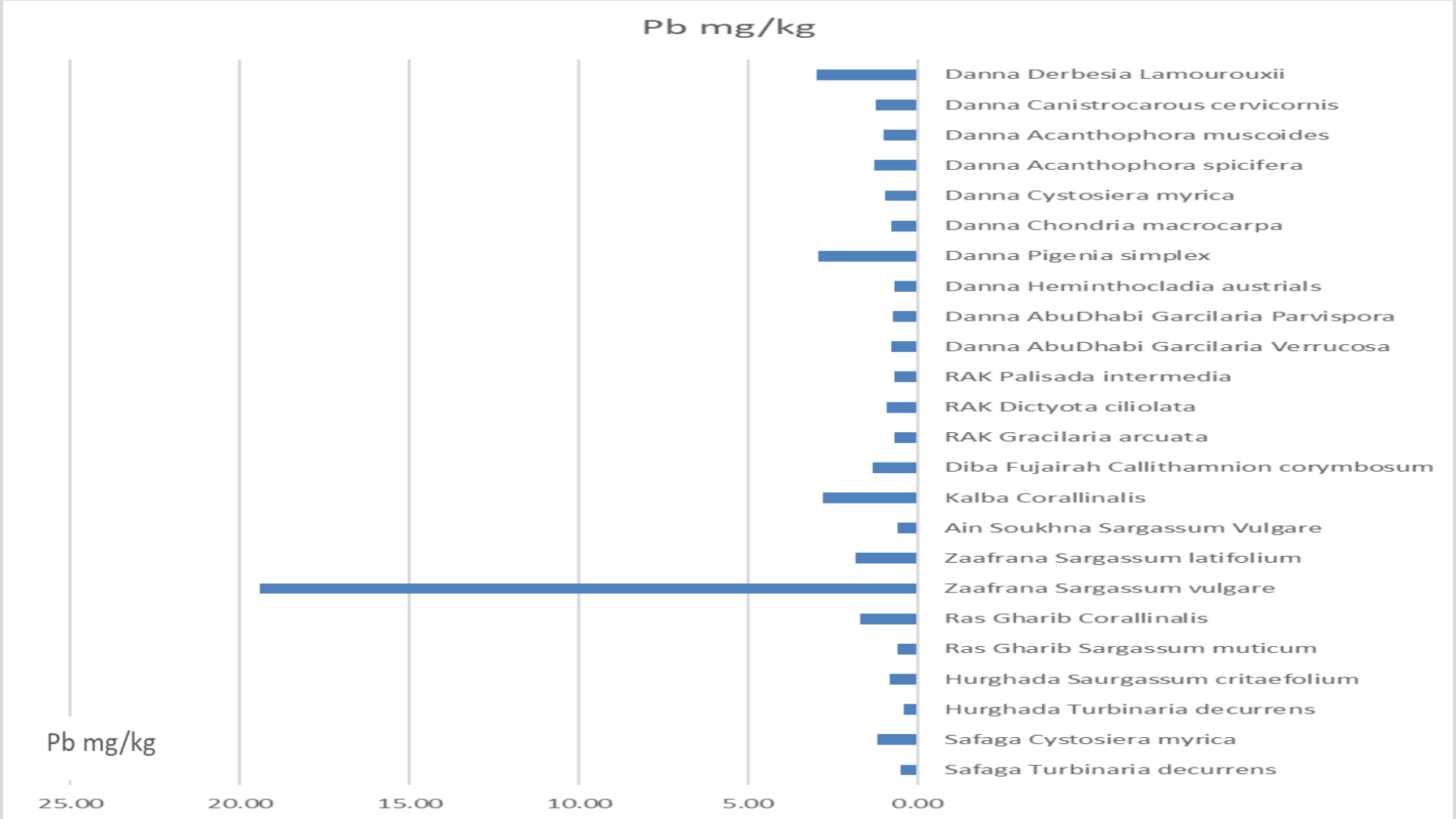
Kalba Corallinalis
Ain Soukhna Sargassum Vulgare
Zaafrana Sargassum latifolium
Zaafrana Sargassum vulgare
Ras Gharib Corallinalis
Ras Gharib Sargassum muticum
Hurghada Saurgassum critaefolium
Hurghada Turbinaria decurrens
Safaga Cystosiera myrica
Safaga Turbinaria decurrens
Zn mg/kg
60.00
50.00
40.00
30.00
20.00
10.00
0.00

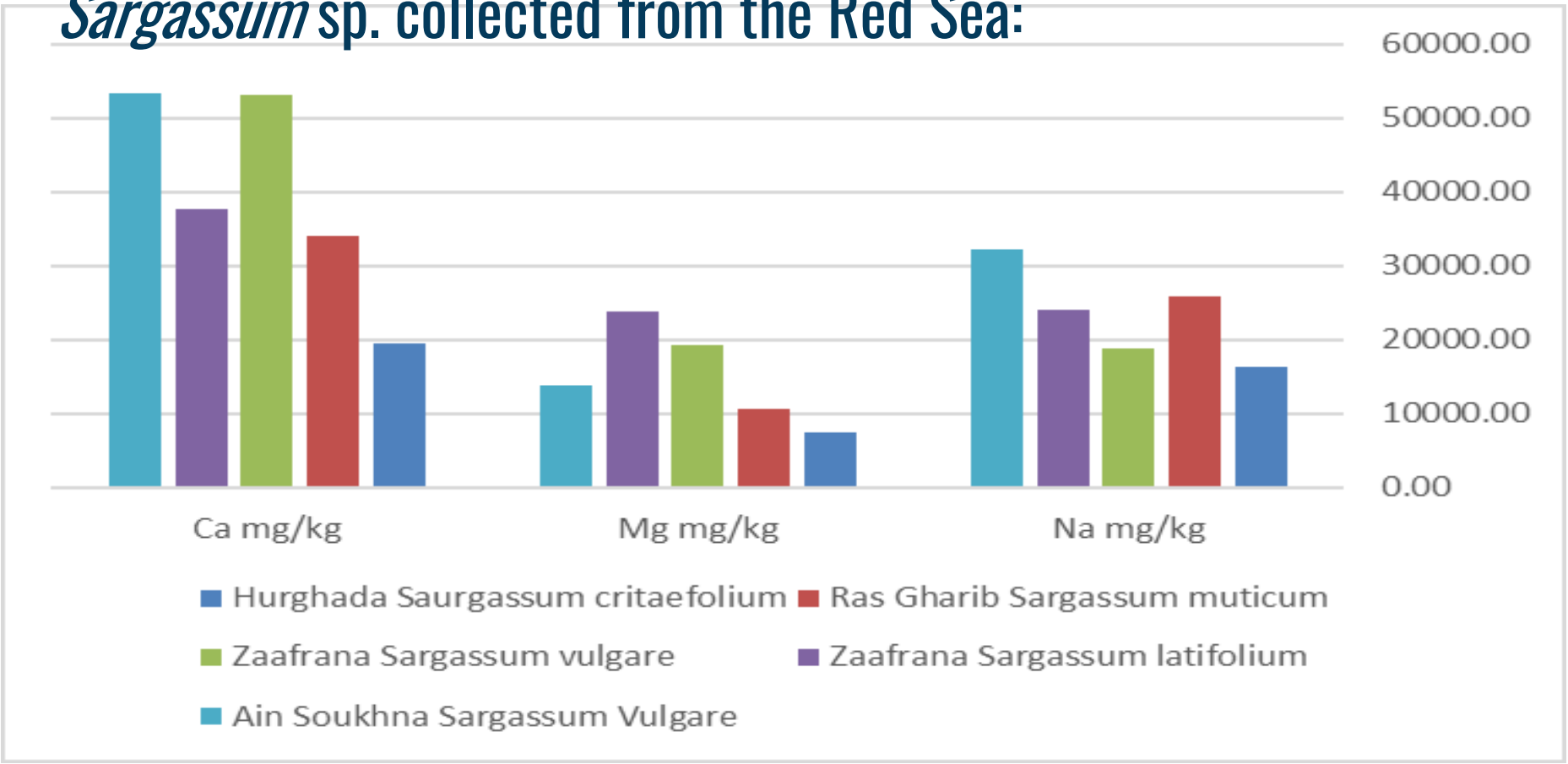

Cu mg/kg
Danna Derbesia Lamourouxii
Danna Canistrocarous cervicornis
Danna Acanthophora muscoides
Danna Acanthophora spicifera
Danna Cystosiera myrica
Danna Chondria macrocarpa
Danna Pigenia simplex
Danna Heminthocladia austrials
Danna AbuDhabi Garcilaria Parvispora
Danna AbuDhabi Garcilaria Verrucosa
RAK Palisada intermedia
RAK Dictyota ciliolata
RAK Gracilaria arcuata
Diba Fujairah Callithamnion corymbosum
Kalba Corallinalis
Ain Soukhna Sargassum Vulgare
Zaafrana Sargassum latifolium
Zaafrana Sargassum vulgare
Ras Gharib Corallinalis
Ras Gharib Sargassum muticum
Hurghada Saurgassum critaefolium
Hurghada Turbinaria decurrens
Safaga Cystosiera myrica
Safaga Turbinaria decurrens
12.00
10.00
8.00
6.00
4.00
2.00
0.00


Cd mg/kg
Danna Derbesia Lamourouxii
Danna Canistrocarous cervicornis
Danna Acanthophora muscoides
Danna Acanthophora spicifera
Danna Cystosiera myrica
Danna Chondria macrocarpa
Danna Pigenia simplex
Danna Heminthocladia austrials
Danna AbuDhabi Garcilaria Parvispora
Danna AbuDhabi Garcilaria Verrucosa
RAK Palisada intermedia
RAK Dictyota ciliolata
RAK Gracilaria arcuata
Diba Fujairah Callithamnion corymbosum
Kalba Corallinalis
Ain Soukhna Sargassum Vulgare
Zaafrana Sargassum latifolium
Zaafrana Sargassum vulgare
Ras Gharib Corallinalis
Ras Gharib Sargassum muticum
Hurghada Saurgassum critaefolium
Hurghada Turbinaria decurrens
Safaga Cystosiera myrica
Safaga Turbinaria decurrens
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00

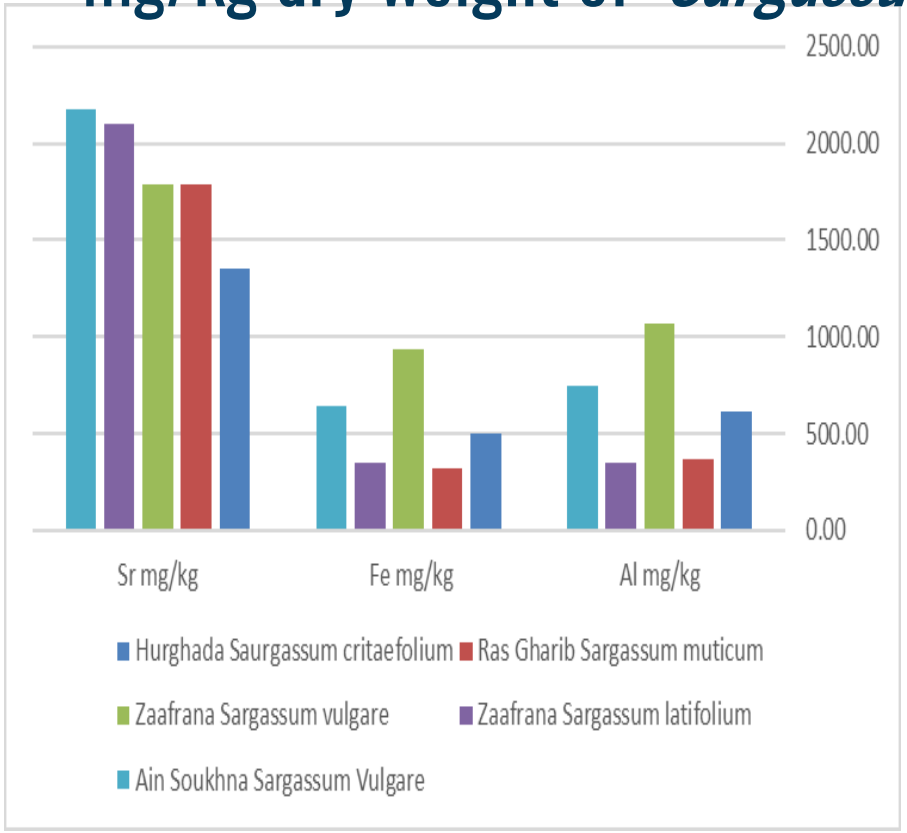

Pb mg/kg
Danna Derbesia Lamourouxii
Danna Canistrocarous cervicornis
Danna Acanthophora muscoides
Danna Acanthophora spicifera
Danna Cystosiera myrica
Danna Chondria macrocarpa
Danna Pigenia simplex
Danna Heminthocladia austrials
Danna AbuDhabi Garcilaria Parvispora
Danna AbuDhabi Garcilaria Verrucosa
RAK Palisada intermedia
RAK Dictyota ciliolata
RAK Gracilaria arcuata
Diba Fujairah Callithamnion corymbosum
Kalba Corallinalis
Ain Soukhna Sargassum Vulgare
Zaafrana Sargassum latifolium
Zaafrana Sargassum vulgare
Ras Gharib Corallinalis
Ras Gharib Sargassum muticum
Hurghada Saurgassum critaefolium
Hurghada Turbinaria decurrens
Safaga Cystosiera myrica
Safaga Turbinaria decurrens
Pb mg/kg
25.00
20.00
15.00
10.00
5.00
0.00

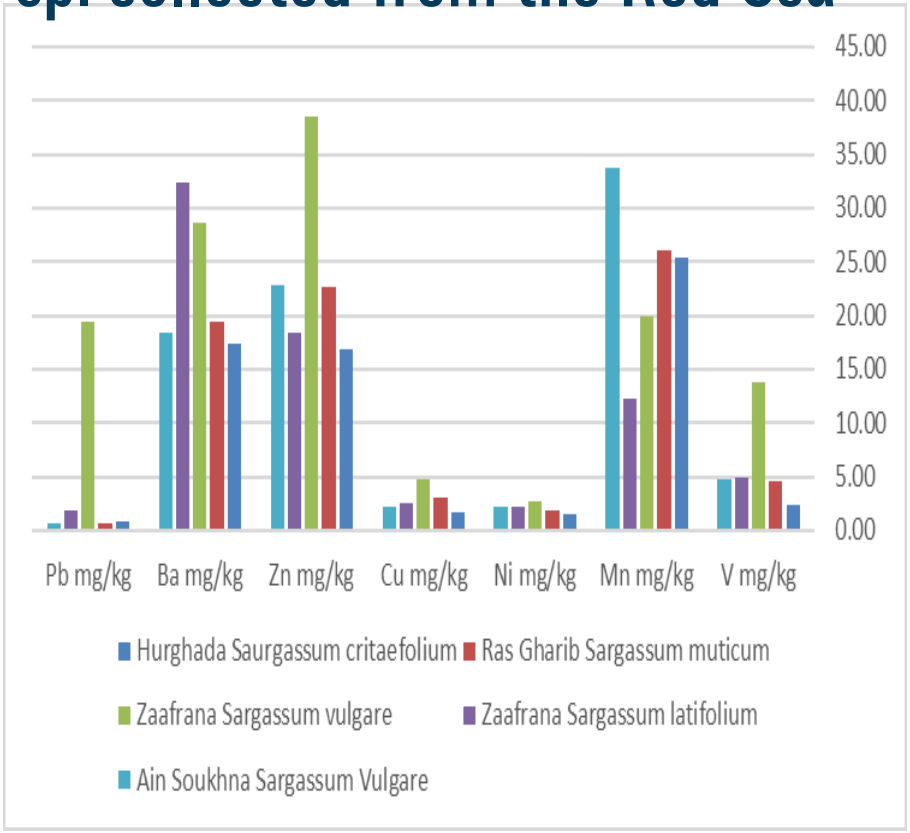
The following charts will discuss the concentration of different elements within the same algae species collected from different locations

The concentration of Ca, Mg and Na in mg/kg dry weight of *Sargassum* sp. collected from the Red Sea:

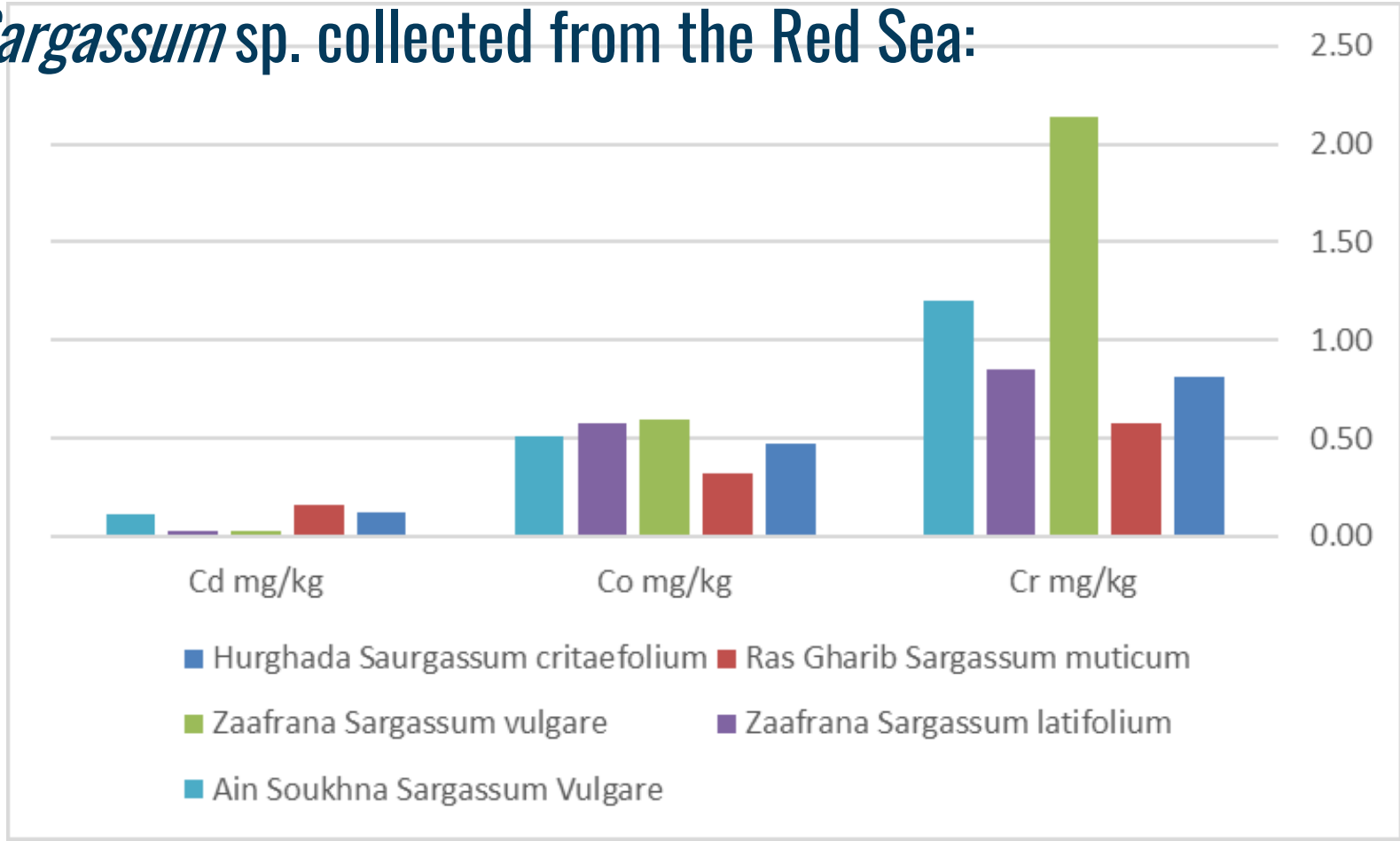


The concentration of Sr, Fe, Al, Pb, Ba, Zn,Cu, Ni, Mn, and V in mg/kg dry weight of *Sargassum* sp. collected from the Red Sea:

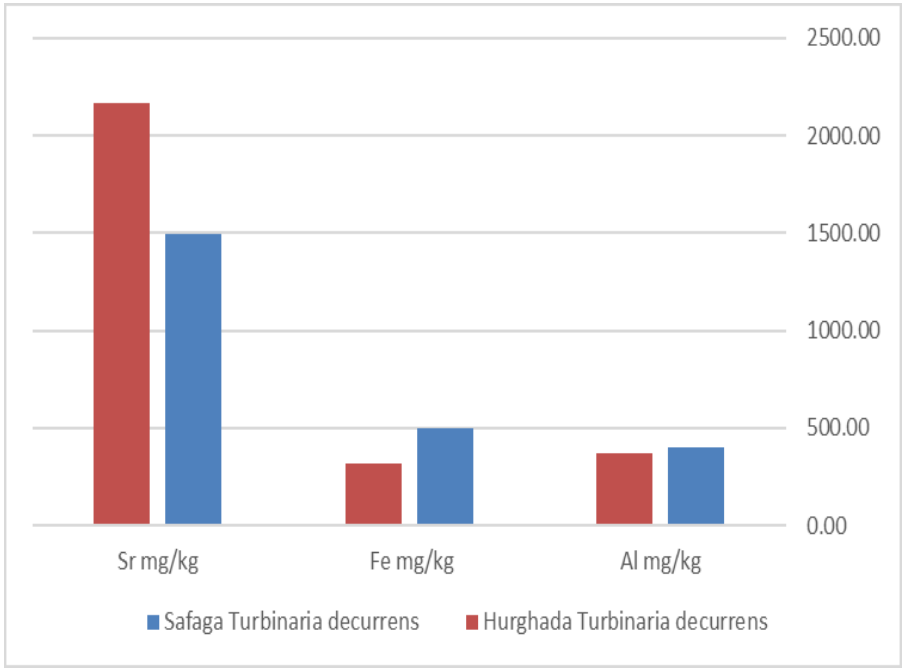


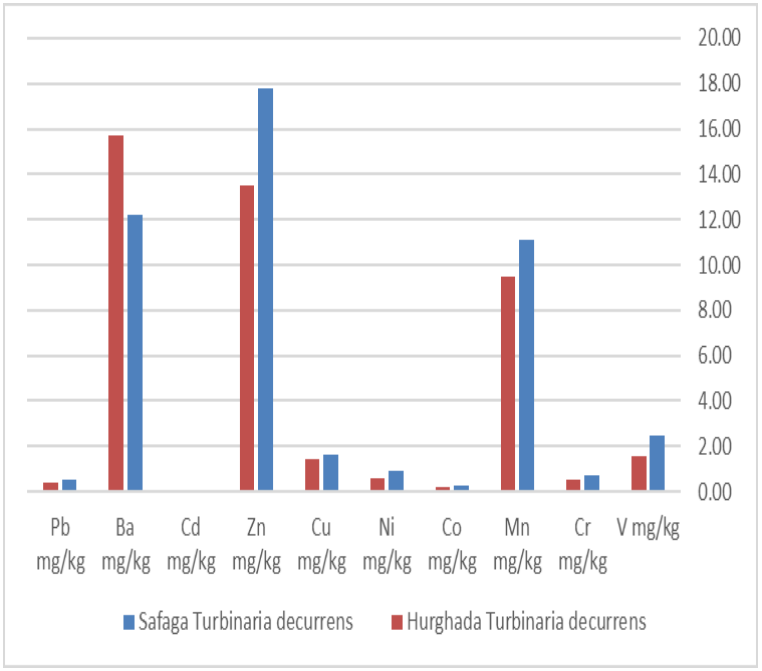


The concentration of Cd, Co and Cr in mg/kg dry weight of *Sargassum* sp. collected from the Red Sea:

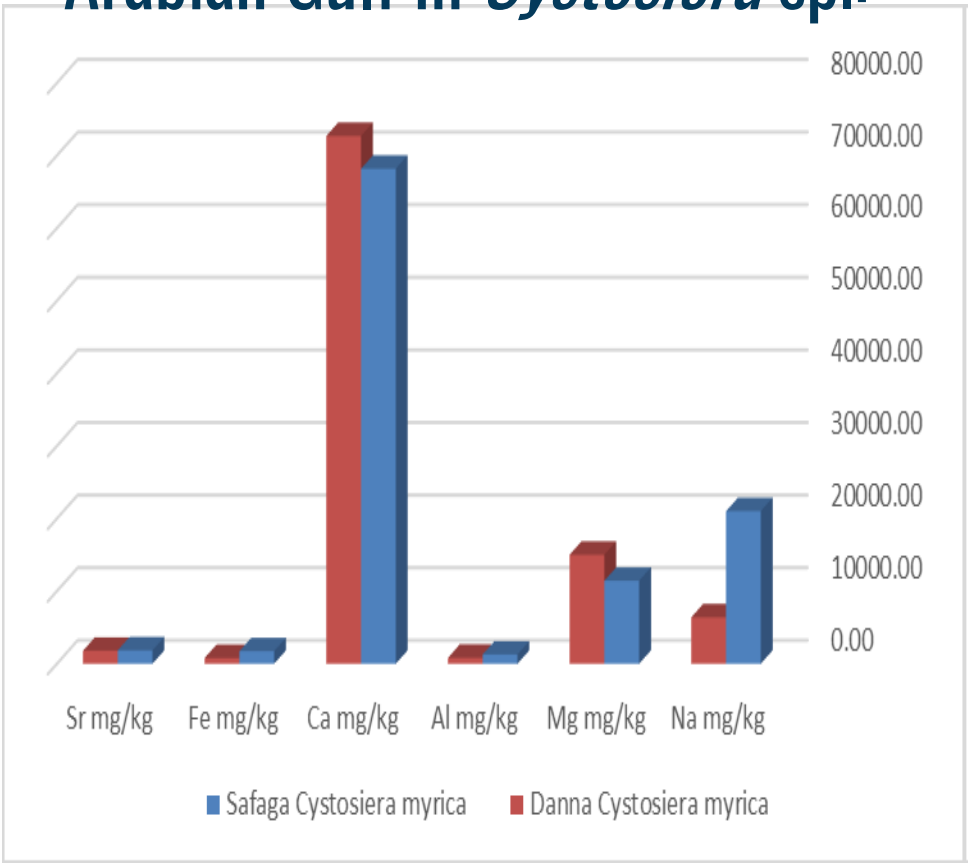


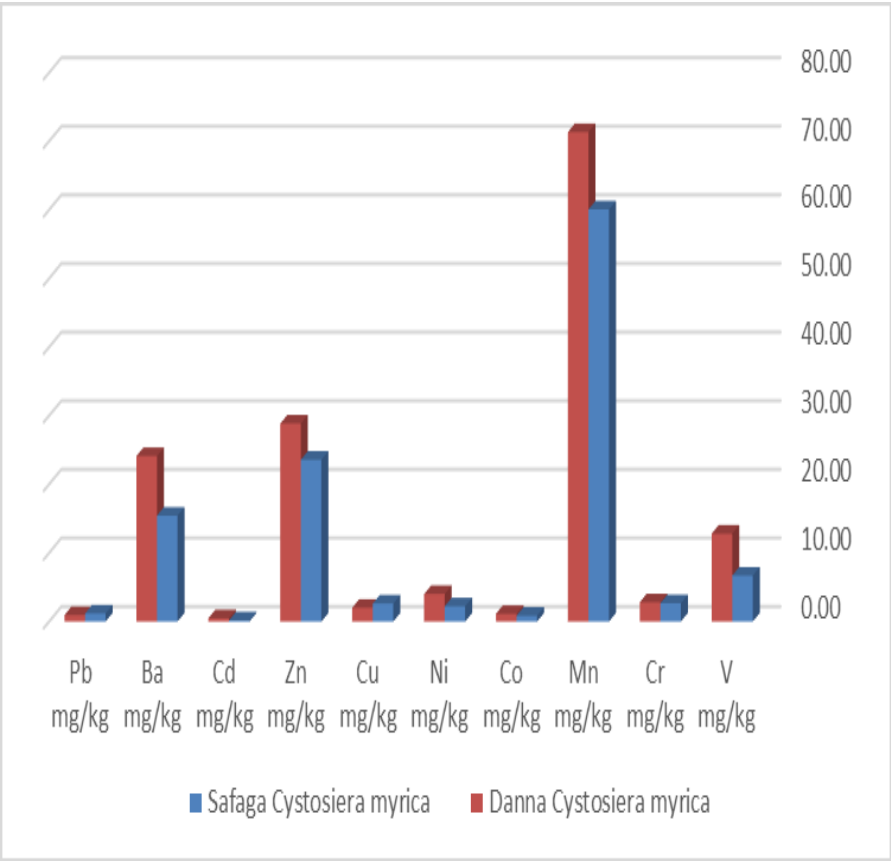
The concentration of Al, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Sr, Cd, Ba and Pb in mg/kg dry weight of *Turbinaria* sp. collected from the Red Sea:



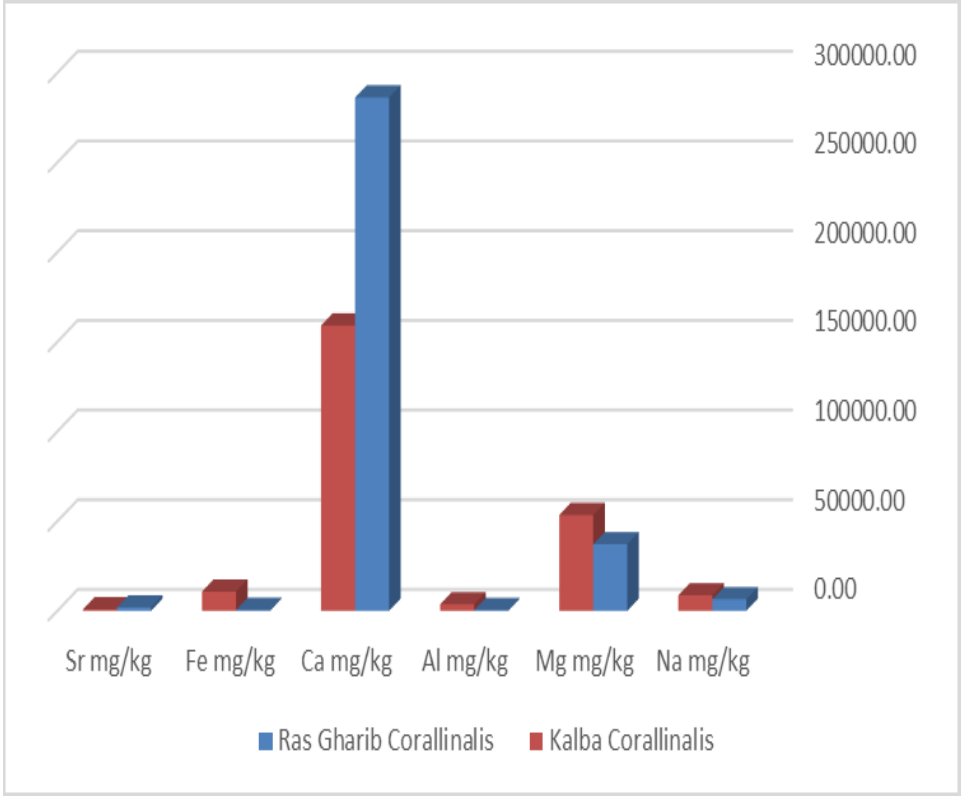


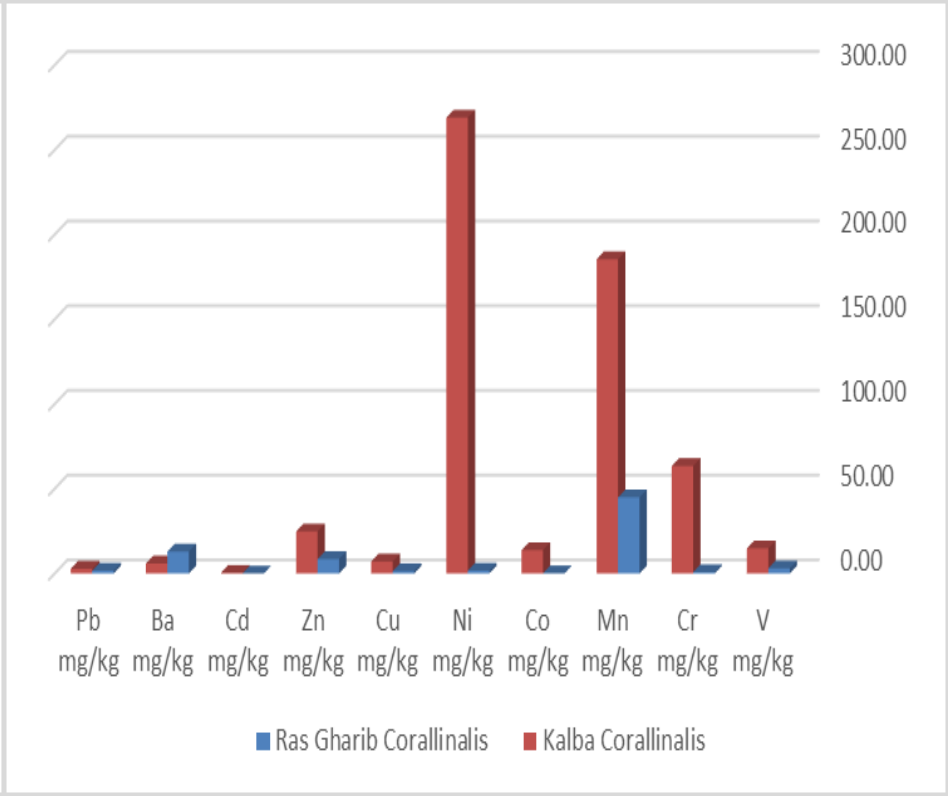
Comparison between elemental content of the Red Sea and The Arabian Gulf in *Cystosiera* sp.:





Comparison between elemental content of the Red Sea and The Gulf of Oman in *Corallinalis* sp.:



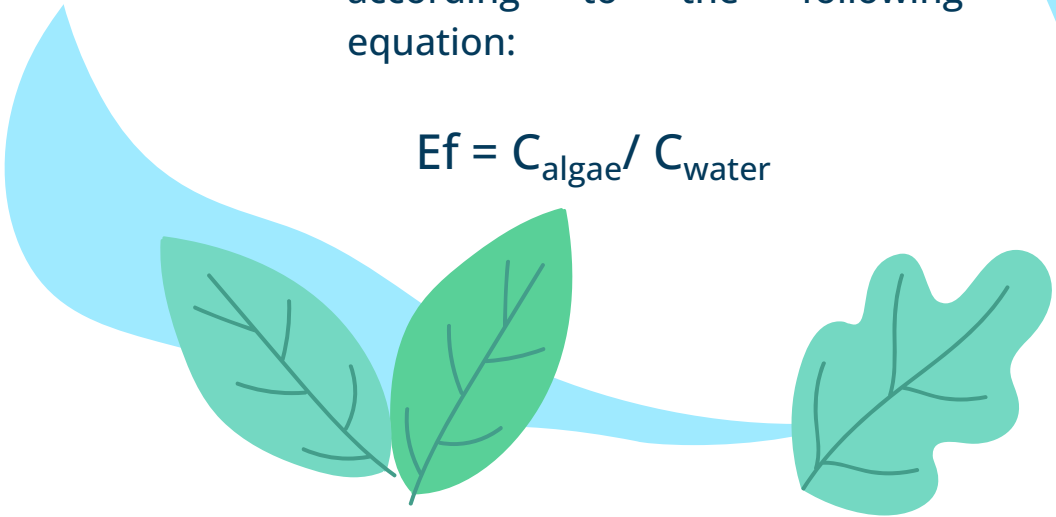


Accumulation Factors

Transfer factor

The Accumulation factor is used to describe the accumulation of a given element in the algal mass with respect to the water, according to the following equation:

$$Ef = C_{algae} / C_{water}$$



Transfere factors among different types of Algae:

	Safaga Turbinaria decurrens	Safaga Cystosiera myrica	Hurghada Turbinaria decurrens	Hurghada Saurgassum critaefolium	Ras Gharib Sargassum muticum	Ras Gharib Corallinalis	Zaafrana Sargassum vulgare	Zaafrana Sargassum latifolium	Ain Soukhna Sargassum Vulgare	Kalba Corallinalis	Diba Fujairah Callithamnion corymbosum	RAK Gracilaria arcuata	RAK Dictyota ciliolata	RAK Palisada intermedia	Danna AbuDhabi Garcilaria Verrucosa	Danna AbuDhabi Garcilaria Parvispora	Danna Heminthocladia austrials	Danna Pigenia simplex	Danna Chondria macrocarpa	Danna Cystosiera myrica	Danna Acanthophora spicifera	Danna Acanthophora muscoides	Danna Canistrocarpus cervicornis	Danna Derbesia Lamourouxii
Na	0.63	0.85	1.2	0.68	1.06	0.27	0.94	1.2	1.41	0.43	0.55	0.83	0.72	0.51	1.39	0.91	0.76	0.35	0.13	0.29	0.64	0.54	0.97	1.12
Mg	2.99	6.13	3.96	4.05	5.67	19.85	12.29	15.23	7.54	32.37	37.72	7.48	4.9	6.66	4.99	4.15	6.54	5.95	9.08	8.64	7.95	5.34	10.88	6.83
Al	10130	32715	9093	14883	7231	8408	17375	5683	6701	127592	79731	24853	40393	22361	8076	16940	14103	57510	12628	20344	22436	16820	17706	92896
Ca	37	135	36	39	71	597	122	86	96	362	268	334	380	157	41	53	67	337	110	178	129	145	138	341
V	1.3	3.48	0.79	1.19	2.4	1.6	7.73	2.77	2.51	8.43	6.9	2.31	14.05	7.01	3.76	3.04	3.36	17.01	6.08	7	7.45	5.92	2.96	7.01
Mn	9253	49929	8156	21922	13892	23967	3188	1964	1632	208020	233739	108304	182300	210992	82439	89748	87780	307863	107529	250690	128226	97690	83809	499693
Fe	47932	167679	27295	43526	10192	16070	18056	6719	4336	3645556	2485372	821424	1397815	766418	41322	63661	66716	284252	59782	89077	97370	72345	74285	448561
Zn	3470	4607	5251	6578	6380	2411	11270	5374	6108	9651	10048	22559	12414	26520	45417	41825	13858	18316	21139	23348	37295	34771	12968	20435
Sr	194	242	296	185	248	268	274	322	259	125	175	159	164	191	20	31	33	220	54	248	67	76	304	209
Ba	1355	1712	1697	1882	1720	1148	2682	3038	1516	344	763	947	1166	1552	290	461	443	1857	503	2013	675	490	2805	2360

Mg

Al

Corallinalis

Ca

Fe

Derbesia Lamourouxi

Na

Mn

Zn

Garcelaria

Conclusion:

1- The concentration of Na, Mg, Al, Ca, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Sr, Cd, Ba, and Pb in 24 samples of algae and 9 samples of water collected from the Red Sea, the Gulf of Oman, the Arabian Gulf were determined using ICP-OES.

2- The highest content of all elements in water samples found in samples collected from the Red Sea, except for Ba, which has its highest value in water samples collected from the Gulf of Oman.

3- Algae samples collected from the Gulf of Oman contained the highest values of Mg, Cr, Mn, Fe, Co, Ni, and Cu, while the content of Pb showed its highest peak in samples collected from the Zaafrana station on the Red Sea, with a value 18 times the average value of Pb among all the samples.

4- The lowest content of V, Cr, Mn, Fe, Ni and Pb were found in samples collected from Hurghada, The Red sea. As well as the lowest values of Co, Cu and Zn found in samples collected from Ras Gharib the Red Sea.

5- *Corallinalins* sp. reflected a high ability to accumulate Mg, Al, Fe and Ca and might be a potential remedial agent, While *Derbesia Lamourouxi* showed a high accumulation ability toward Na and Mn and *Garcilaria* sp is a good accumulator for Zn and might be a potential remedial agent for Zn absorption and removal.

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I dedicate my deepest appreciation.

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Professor of Nuclear physics, Faculty of science, Cairo University

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Head of analysis department
Joint Institute of Nuclear research

Thank you

Prof. Marina Frontasyeva

Thanks!

Do you have any questions?

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