METAL LEVELS IN COMMON SEAWEEDS FROM SUEZ BAY

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Abstract

Metal levels (Cd, Co, Cr, Cu, Mn, Fe, Pb, Ni and Zn) were determined in water and 24 species of seaweeds at 8 sites on Suez Bay close to the industrial and urban zone, from March 1998 through February 1999. The seaweeds of the Suez Bay contribute competently for elimination of trace metals from the water. The levels of metal in seawater were between 0.105 ppb for chromium and 20.76 ppb for zinc. In seaweed species, the levels were between 1.93 ppm for chromium and 1528.89 ppm for iron. Many species have high capacity for absorption of certain metals, making them good bioremediators. At the forefront, *Cladophoropsis zollingeri* (Chlorophyta) accumulated Cr, Fe, and Mn at 70, 112, and 306 times their levels in seawater. For Cd, Co, and Pb, calcareous algae such as *Jania rubens, Halimeda tuna,* and *Galaxaura oblongata* are good bioremediators. They accumulated 29, 32, and 34 times the levels measured in seawater.

Keywords: bioremediators, Suez Bay, trace metals, seaweeds, metal pollution.

Introduction

Although trace metals at low concentrations are essential to life, at high concentrations they may become hazardous. The imposition of stricter environmental regulations increases the demand for more competitive, effective and economically treatment methods for removal and recovery of toxic metals from industrial effluents which is a scientific challenge.

Aquatic plants provide a viable alternative for metals remediation if proper disposal of spent plants can be employed (Ray and Ray, 2002). Aquatic macrophytes are known to remove metals by surface adsorption and/or absorption and incorporate them into their own system or store them in a bound form (Rai *et al.*, 1995; Espinoza-Quinones *et al*., 2005). Since early 1970s several works have demonstrated that seaweeds can be used to partially strip trace metal in the marine waters (Folsom *et al.*, 1963; Folsom and Young, 1965; Phillips, 1977, 1993, Langston, 1986; Malea and Haritonidis, 2000; Garrison, 2004).

Suez Bay (Fig. 1) is surrounded by an industrial zone with three oil refineries, three power stations, fertilizer, steel and textile factories, which could be a source of many pollutants including trace elements. Navigation activities in Suez Canal, Port Tawfik and Adabyea harbors may also form another source of trace elements. The aim of this work was to investigate Cd, Co, Cr, Cu, Mn, Fe,

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Pb, Ni and Zn meditation in Suez Bay seawater and evaluate the efficiency of its seaweeds in metal remediation.

The study area:

The Suez Bay (Fig.1) is located at the end of the Gulf of Suez between (Long. 32 ° 28\ & 32 ° 34\ E) and (Lat. 29° 54\ & 29° 57\ N) with an area of 77.13 Km^2. Its depth is 10 m in average but there is a navigation channel of 12 m depth connecting the bay with the Gulf of Suez and Suez Canal. The current direction is generally anti-clockwise, from north to south. Selection of sampling sites was based on the water current direction and sources of pollution in Suez Bay. Site (I) is located at Eion Mousa and has no land-based pollution sources.

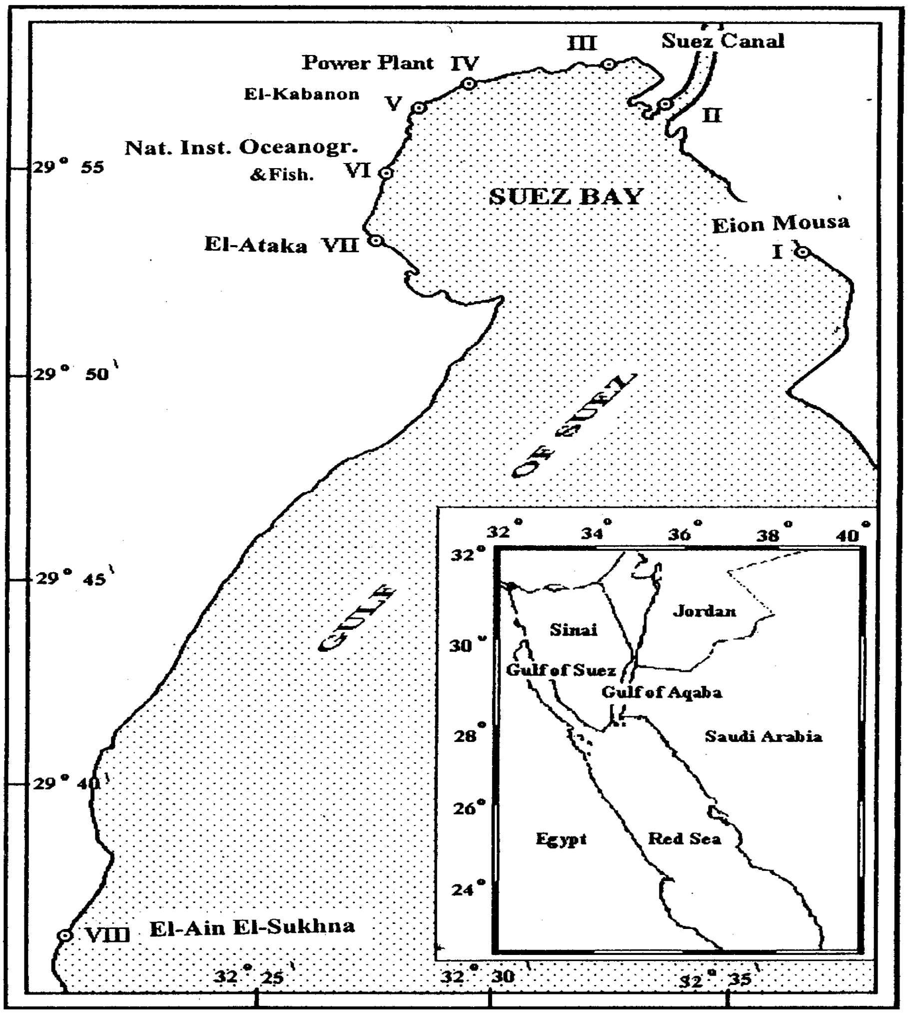

Figure (1): The investigated sites at Suez Bay. Inset: Red Sea.

Site (II) is located Port Tawfik, the southern entrance of the Suez Canal and is affected by the pollutants of navigation activities. Site (III) is located near a shipbuilding and maintenance workshops. Site (IV) is located in the middle of the bay and is affected by the effluent discharges from Suez Petroleum Company, Thermal Power plant and untreated sewage of El-Mamal dwelling zone. Site (V) is located at El-Kabanon zone and is affected by untreated sewage from the Suez City and effluents from El-Nasr Fertilizers Company. Site (VI) is directly affected by industrial soluble wastes from textile and palm oil factories, dust from a steel factory, and a sewage treatment plant output 2 Km off shore. Site (VII) is located close to El-Ataka fishing harbor and could be affected by the antifouling paints. Site (VIII) is located at Ein-Elsukhna, 60 Km south of Suez, where the shore has rocks, dead corals and sandy pools, all are covered with oil deposits.

Materials and Methods

Seaweed samples were monthly collected from the intertidal zone from March 1998 through February 1999. Identification of the species was carried out using standard references (e.g., Aleem, 1993; Børgesen, 1957; Dawson, 1962; Jaasund, 1977). For analysis, algal samples were thoroughly washed with distilled water and stored in plastic pages at -20^{o}C. The frozen algae were thawed, washed with distilled water, allowed to dry and powdered in a PVC mortar. Two liters of surface water were collected in colorless polyethylene bottles, acidified and filtered through a pre-weighed 45um GF. The dissolved trace metals were measured in seaweeds and seawater using the method described by Brook *et al.* (1967) and a flame photometer AAS (Perkin Elmer 301), and expressed in ppm and ppb, respectively.

Results and Discussion

Trace metals in seawater

Table (1) shows the annual mean and standard deviation of the dissolved nine metals measured in seawater at different sites. Trace metal levels were in the sequence of Zn > Fe > Pb > Ni > Cu > Co > Cd > Mn > Cr. The higher annual mean level of zinc was 20.76 ppb and the lower annual mean level of Cr was 0.105 ppb. Zinc levels in this study were very high as compared with previous work in Suez Bay and other areas of the world. Other elements were in comparable levels to those measured in non-polluted and may be lower than the quality standards in coastal waters (Harper, 1988; Hester and Harrison, 2000; Garrison, 2004).

Dissolved cadmium showed total annual mean of 0.272 ± 0.178 ppb. The level at different sites was 0.217-0.339 ppb. Abdel-Azim (1996) and El-Moselhy *et al.* (1999) found dissolved cadmium of 0.26 - 0.87 ppb in Suez Bay water. This level is lower than the quality standards (2.50 ppb Cd) recommended by the

Table (1): The annual mean and standard deviation (SD) of the dissolved metals (ppb) in seawater at different sites for each metal

Metal	Cd		Co		Cr		Cu		Fe		Mn		Ni		Pb		Zn	
Sites	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD
I	0.217*	0.094	0.343	0.079	0.109	0.043	0.802*	0.296	13.60**	10.09	0.211**	0.143	0.773*	0.314	1.460**	0.561	23.61**	10.67
II	0.248	0.230	0.378**	0.151	0.098	0.045	0.911	0.372	10.09	5.053	0.200	0.107	0.905	0.495	1.142	0.439	19.12*	8.180
III	0.305	0.163	0.307	0.105	0.107	0.064	1.153	0.533	9.472	7.401	0.163	0.090	1.088	0.593	1.166	0.537	20.65	10.25
IV	0.276	0.199	0.267*	0.116	0.102	0.050	1.173**	0.906	5.658*	1.428	0.144*	0.066	1.025	0.394	0.921	0.630	20.29	11.14
V	0.249	0.117	0.300	0.105	0.092*	0.050	0.851	0.349	10.08	9.808	0.149	0.076	0.852	0.355	0.912*	0.380	20.20	8.300
VI	0.339**	0.254	0.348	0.108	0.102	0.056	0.965	0.425	8.146	3.483	0.155	0.067	1.220**	0.499	1.028	0.282	20.02	8.750
VII	0.319	0.219	0.367	0.112	0.100	0.048	1.045	0.701	9.627	5.956	0.180	0.082	0.951	0.346	1.149	0.377	19.79	11.52
VIII	0.219	0.148	0.353	0.139	0.129**	0.086	0.879	0.556	7.252	4.691	0.176	0.089	0.891	0.399	0.992	0.291	22.39	9.610
Mean	0.272	0.178	0.333	0.114	0.105	0.055	0.972	0.517	9.24	5.988	0.172	0.092	0.963	0.424	1.096	0.437	20.76	9.80

*= Low level of metal; ** = High level of metal.

European Community for dissolved metals in coastal waters (Harper, 1988). Cadmium level in seawater depends mainly on the dissolved fraction (Dowidar and El-Nady, 1987).

Dissolved cobalt showed total annual mean of 0.33 ±0.11 ppb. The level at different sites was 0.267 - 0.378 ppb. Hamed (1996) found lower level of 0.10 - 0.70 ppb, while EL-Moselhy *et al.* (1999) found 0.33 - 0.73 ppb in Suez Bay water.

Dissolved chromium showed total annual mean of 0.11 ±0.06 ppb. The level at different sites was 0.092 - 0.129 ppb. The variation of chromium level may be related to plankton growth (Brewer, 1975) and bacterial decomposition of organic matter (Forstner and Wittmann, 1981). The chromium level in this study exceeded the standard limit in unpolluted seawater (0.08 ppb Cr, Cranston and Murray, 1978). Muse *et al.* (1999) found 0.04- 0.50 ppb of dissolved Cr in south Atlantic, Argentina.

Dissolved cupper showed total annual mean of 0.972 ±0.517 ppb. The level at different sites was 0.802 - 1.173 ppb. El-Moselhy (1993) found a level of 0.71 - 5.50 ppb in Suez Bay; later on the level was lowered to 1.13 - 2.62 (EL-Moselhy *et al.*, 1999). Variation in dissolved copper may be attributed to chelation by particulate organic matter and algal growth (Forstner and Wittmann, 1981). In non-polluted oceanic waters, cupper was measured at levels ranging from 0.02 to 3.00 ppb (Goldberg, 1965; Preston *et al.*, 1972; Boyale *et al.*, 1977; Bruland and Frankie, 1983; Jaleel *et al.*, 1993; Muse *et al.* (1999).

Iron is the most abundant element in the seawater and occurs mainly in a particulate phase as a result of the formation of Fe (III) in well-oxygenated seawater (Dowidar and El-Nady, 1987). Dissolved iron showed total annual mean of 9.24 ±5.988 ppb. The level at different sites was 5.658-13.600 ppb. The higher value (13.600 ppb) was found at site I and may be resulted from the corrosion of submerged military wrecks. The lower value was measured at site IV may be, as suggested by Forstner and Wittmann (1981), due to chelation of dissolved ions by particulate organic matter from the untreated sewage. Sites II and VI showed high iron levels as they receive dust waste of a steel factory. The present dissolved level of iron is comparable to that measured in many areas of the world (e. g. Magnusson and Rasmussum, 1982; Jickells and Knap, 1984; Emara *et al.*, 1995).

Dissolved manganese showed total annual mean of 0.0.17 ±0.09 ppb. The level at different sites was 0.144 – 0.211 ppb. The levels are the same with those measured by Goldberg (1965) and Hamed (1996) in Suez Bay water. Level was high at sites I and II. The terrestrial source from local mountains and desert may be the source especially during the windy months (Li and Chin, 1997). The consumption by algae may be the reason for low level at other sites. Manganese is essential element in glucose utilization of living organisms (Forstner and Wittmann, 1981).

Dissolved nickel showed total annual mean of 0.963 ±0.424 ppb. The level at different sites was 0.773 – 1.220 ppb. Sites III, IV and VI showed the higher levels measured in the seawater. These sites are nearby Nasr Petroleum Company, sewage effluents, and shipbuilding. Dean *et al.* (1972) and Forstner and Wittmann (1981) stated that steel works and oil industry are major sources for nickel. Nickel level in this study is less than the standard limit (2.00 ppb; Goldberg, 1965; Waldichut, 1974).

Dissolved lead showed total annual mean of 1.096 ± 0.437 ppb. The level at different sites was 0.912 - 1.460 ppb. The higher level several sites may be, as mentioned by Jickells and Knap (1984) due to atmospheric fallout from oil refineries in the region. In all conditions, lead levels were much lower than the standard limit (25.00 ppb) recommended by the European Community for dissolved metals in coastal waters (Harper, 1988). Lead forms poorly soluble salts that have low mobilization (Forstner and Wittmann, 1981)

Zinc is one of the most abundant essential elements, approximately 100 times as copper (Forstner and Wittmann, 1981). Dissolved zinc showed total annual mean of 20.760 ± 9.80 ppb. The level at different sites was 19.12 – 23.61 ppb. The anti-fouling paints at Adabyea and Ataka Harbours with the Suez Company for fertilizers are the major source of zinc. Zinc levels in this study were high as compared with previous work in Suez Bay and other areas of the world. In the Suez Bay, El-Moselhy (1993) found 1.30-7.71 ppb dissolved zinc; El-Moselhy *et al.* (1999) found 4.30-12.12 ppb. Goldberg (1965) reported average concentration of 10 ppb of zinc in water from World Ocean. Magnusson and Rasmussen (1982) found 0.80 ppb of dissolved zinc in the Danish Coastal water. Jickells and Knap (1984) found dissolved zinc of 0.30 ppb in seawater from Bermuda.

Trace metals in seaweeds

Table (2) shows the mean levels of the nine metals measured in 24 species, 8 Chlorophyta, 9 Phaeophyta, and 7 Rhodophyta. The total average in all species was in the sequence of Fe > Zn > Mn > Pb > Ni > Cd > Co > Cu > Cr. This sequence disagreed with that recorded in water.

The level of cadmium in studied Chlorophyta seaweed was varied between 1.93 ppm in *Bryopsis plumose* and 10.93 ppm in *Halimeda tuna*. This level is 9 to 32 times its level in seawater. The higher level of cadmium in *Halimeda tuna* may be referred to its calcareous structure. Other non calcareous Chlorophyta are lower than *Halimeda* and this is found to be in accordance with the result given by Shiber (1980) from Lebanon, Jaleel *et al.* (1993) from Arabian Sea, El-Sarraf (1995) from Alexandria, and Muse *et al.* (1999) from Argentina. Cadmium levels in Phaeophyta were lower than Chlorophyta. In the former group, the level was between 4.22 ppm in *Padina pavonica* and 2.172 ppm in *Stypopodium zonale*.

Table (2): Mean level of trace elements (ppm dry wt.) in the selected seaweeds for each metal

Species	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Zn
Chlorophyta									
Bryopsis plumosa	1.93*	3.59	4.04	6.51	1147.06	23.76	7.12	26.38	48.21
Caulerpa racemosa.	3.91	4.09	2.09	3.60	891.89	25.10	6.58	19.64	35.96
Chaetomorpha linum	4.41	4.41	3.29	4.70	876.55	23.30	7.10	24.43	52.90
Cladophora serica	3.29	5.85	7.92	10.36**	1343.04	42.32	11.97	31.70	65.95
Cladophoropsis zollingeri	3.76	7.46	9.03**	10.17	1528.89**	64.65**	12.73	37.29	49.67
Enteromorpha intestinalis	3.05	4.67	4.98	8.41	1226.12	25.11	12.27	27.50	55.08
Halimeda tuna	10.93**	10.40	3.08	6.10	1163.10	29.47	13.98	43.27	37.13
Ulva lactuca	3.23	3.61	2.17	7.16	689.42	19.61	8.79	31.86	38.94
Phaeophyta									
Colpomenia sinuosa	3.00	5.60	4.46	5.51	1236.83	43.05	9.45	28.82	22.50
Cystoseira myrica	3.40	4.65	3.47	3.74	1150.09	37.45	7.30	17.69	36.50
Dictyota dichotoma	3.67	4.55	3.47	6.66	1263.31	37.28	7.69	20.91	23.27
Giffordia mitchellae	2.50	5.14	3.87	5.29	1347.55	33.03	8.50	24.31	27.67
Hydroclathrus clathratus	3.00	5.78	3.59	3.17	1439.46	61.55	9.35	23.04	70.52**
Padina pavonica	4.23	6.86	3.61	4.86	1113.66	62.04	16.65**	29.68	27.79
Sargassum latifolium	2.72	3.81	1.95	3.72	773.81	24.24	6.28	20.30	20.31
Stypopodium zonale	2.17	5.08	3.90	9.04	1192.58	44.24	8.00	23.43	30.33
Turbinaria triquetra	3.07	2.04*	0.14*	1.47*	185.59*	7.23*	3.63*	12.58*	12.46*
Rhodophyta									
Acanthophora najadiformis	3.10	5.06	2.57	7.05	1213.90	44.47	8.34	21.15	58.36
Chondria seticulosa	2.81	6.37	5.34	5.54	1319.23	39.08	9.49	23.54	68.73
Galaxaura oblongata	5.42	10.84**	4.93	9.07	1083.60	58.95	14.50	40.93	47.09
Hypnea cornuta	2.44	3.33	2.76	7.58	686.76	14.93	6.15	15.92	45.95
Jania rubens	4.98	10.42	3.60	4.37	1254.22	56.28	13.41	50.25**	41.30
Laurencia papillosa	3.03	5.02	4.34	4.66	1080.77	48.00	11.08	23.79	44.72
Liagora farinosa	5.18	10.00	4.27	4.85	1119.84	41.35	12.79	43.25	27.38
Total average	3.72	5.78	3.87	5.98	1096.97	37.77	9.71	27.57	41.2

*= Low level of metal; ** = High level of metal.

Rhodophycean species displayed levels between 5.417 ppm in *Galaxaura* and 2.44 ppm in *Hypnea*. The calcareous structures of *Galaxaura*, *Liagora*, and *Jania* may increase their ability to accumulate cadmium than the other non calcareous species and there are in accordance with the measurement given by El-Sarraf (1995) from Alexandria and Wahbeh (1985) from Gulf of Aqaba.

Cobalt is an essential element for living organisms (Moore, 1991). The level of cobalt in studied seaweed was varied between 2.04 ppm in *Turbinaria triquetra* (Phaeophyta) and 10.84 ppm in *Galaxaura oblongata* (Rhodophyta). This level is 8 to 29 times its level in seawater. *Liagora farinose* and *Jania rubens* (Rhodophyta) and *Halimeda tuna* (Chlorophyta) also accumulate 10 ppm approx. All of these species with *Galaxaura* are calcareous algae, and this character may increase the efficiency of cobalt accumulation. *Cladophoropsis zollingeri, Padina pavonica,* and *Chondria seticulosa* were good remediators of cobalt as they accumulated 7.46, 6.86, 6.37 ppm, respectively. The present levels of cobalt are more or less in accordance with those recorded by Seanko *et al.* (1976) from Japan.

The level of chromium in studied seaweed was varied between 0.14 ppm in *Turbinaria triquetra* (Phaeophyta) and 9.03 ppm in *Cladophoropsis zollingeri* (Chlorophyta). This level is 2 to 70 times its level in seawater. *Cladophora serica* (Chlorophyta) and *Chondria seticulosa* (Rhodophyta) accumulated 7.92, 5.34 ppm, respectively. Other algae showed concentration lower than 5 ppm. Seanko *et al.* (1976) recorded Cr levels between 3.5 and 23.4 ppm in similar species from Japan, meanwhile Muse *et al.* (1995) found similar levels from Gulf of San Jorge, Argentina.

The level of cupper in studied seaweed was varied between 1.47 ppm in *Turbinaria triquetra* (Phaeophyta) and 10.36 ppm in *Cladophora serica* (Chlorophyta). This level is 2 to 9 times its level in seawater. Fourteen of the studied species contained 5-10 ppm of cupper (Table 2). Many literatures recorded cupper in levels that highly exceed the present values. In Gulf of Aqaba, Wahbeh (1985) found levels of 42.1, 48.1, 50, 55.3, 59.5 ppm in *Ulva lactuca*, *Liagora turneri*, *Laurancia obtuse*, *Halimeda tuna*, and *Galaxaura lapidescens*, respectively. From Kuwait coast on the Arabian Gulf, Buo-Olayan and Subrahmanyam (1996) found 45, 150, 60-120, and 85-120 ppm in *Cladophora ceolorix*, *Cladophoropsis* sp., *Enteromorpha* sp., and *Ulva lactuca*, respectively. Cupper is the second most toxic metal after mercury. Cupper sulfate is used to control nuisance algae in freshwater. Even though, it is an essential micronutrient. Its toxicity is dependent on the ionic activity (the free Cu^{+2}) and not the total salt. The lowest toxic Cu^{+2} concentration for sporophytes of *Laminaria hyperborea* was 3.3 times its concentration in the water (Zamuda and Sunda, 1982).

Iron is an essential element for plants especially for chlorophyll and oxidation-reduction reactions (Park and Plock, 1971). The level of iron in studied seaweed was varied between 185.59 ppm in *Turbinaria triquetra* (Phaeophyta) and 1528.89 ppm in *Cladophoropsis zollingeri* (Chlorophyta). This level is 33 to 112 times its level in seawater. Nineteen of the 24 studied species accumulated more than 1000 ppm of cupper (Table 2), and many of which were either calcareous or fleshy. Sivalingam (1978) found very high iron levels of 4735.5-7117.6 ppm in many similar species of seaweeds, however almost other studies showed levels similar to this study (Agadi *et al.,* 1978; Wahbeh, 1985; El-Sarraf, 1995; Malea *et al.,* 1995; Buo-Olayan and Surahmanyam, 1996).

The level of manganese in studied seaweed was varied between 7.23 ppm in *Turbinaria triquetra* (Phaeophyta) and 64.65 ppm in *Cladophoropsis zollingeri* (Chlorophyta). This level is 50 to 306 times its level in seawater. Except *Turbinaria, Hypnea* and *Ulva,* other species contained prominent values over than 20 ppm (Table 2). Agadi *et al.* (1978) found very high Mn levels of 2685.53, 111.25-1721.51, and 74.58 ppm in *Enteromorpha clathrata, Ulva* spp. and *Caulerpa sertutaroides* from Goa coast, India. Buo-Olayan and Surahmanyam 1996, found similar Mn levels of 75 ppm in *Cladophoropsis* sp. and 55-71 ppm in *Enteromorpha* spp. but higher of 20-75 ppm in *Ulva lactuca* from Kuwait coast.

Nickel is a non-essential element for the living organisms. It is used as a catalyst in oil refineries. The level of nickel in studied seaweed was varied between 3.63 ppm in *Turbinaria triquetra* and 16.65 ppm in *Padina pavonica,* the two species from Phaeophyta. This level is 5 to 14 times its level in seawater. *Cladophora serica, Cladophoropsis zollingeri,i Enteromorpha intestinalis,* and *Halimeda tuna* from Chlorophyta accumulated 11.97, 12.73, 12.27, 13.98 ppm, respectively. *Galaxaura oblongata, Jania rubens, Laurencia papillosa,* and *Liagora farinose* from Rhodophyta accumulated 14.50, 13.41, 11.08, and 12.79 ppm, respectively. All species in this study showed Ni levels higher than the limit concentration (1 ppm) of the unpolluted seaweeds (Riley and Skirrow, 1965 and Tomlinson *et al.,* 1980).

Lead is a non-essential for living organisms. It inhibited the respiration when corn (a terrestrial plant) was exposed to lead, but when inorganic phosphate was added, there was no inhibition. Lead appeared to bind with phosphate and precipitate (Koeppe and Miller, 1970). The chloroplast ultrastructure of the freshwater plant *Ceratophyllum demersum* was altered when exposed to various levels of lead and inorganic phosphate (Rebechini and Zegers, 1972). On the other hand, sedentary (benthic) algae have high capacity for absorption of lead with no alteration, making them good indicators for lead (Forstner and Wittmann, 1981). The level of lead in studied seaweed was varied between 12.58 ppm in *Turbinaria triquetra* and 50.25 ppm in *Jania rubens* (from calcareous Rhodophyta). This level is 14 to 34 times its level in seawater. Other calcareous algae also contained high levels; *Halimeda tuna* (43.27 ppm), *Liagora farinose* (43.25 ppm), and *Galaxaura oblongata* (40.93 ppm).

Zinc is an essential element for plant life and participates in photosynthesis (Park and Plock, 1971). The level of zinc was varied between 12.46 ppm in *Turbinaria triquetra* (Phaeophyta) and 70.52 ppm in *Hydroclathrus clathratus* (Phaeophyta). The studied seaweeds had low ability to accumulate zinc. The present level is calculated as 0.7 to 3 times its level in seawater. From Kuwait coast, Buo-Olayan and Subrahmanyam (1996) found very high levels of 200, 425, and 192- 610 ppm in *Cladophora*, *Enteromorpha,* and *Padina*. Almost other studies showed levels similar to this study (Agadi *et al.,* 1978; Wahbeh, 1985; El-Sarraf, 1995).

In conclusion, the benthic algae in Suez Bay contribute competently for elimination of trace metals from the water. Many species have high capacity for absorption of certain metals, making them good bioremediators. At the forefront, *Cladophoropsis zollingeri* (Chlorophyta) accumulated Cr, Fe, and Mn at 70, 112, and 306 times their levels in seawater. For Cd, Co, and Pb, calcareous algae such as *Jania rubens, Halimeda tuna,* and *Galaxaura oblongata* are good bioremediators. They accumulated 29, 32, and 34 times the levels in seawater.

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مستويات المعادن الثقيلة فى الطحالب البحرية الشائعة بخليج السويس

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قيست مستويات معادن الكدميوم والكولبت والكروم والنحاس والمنجنيز والحديد والرصاص والنيكل والزنك فى أنسجة 24 نوعا من الطحالب البحرية فى ثمان محطات على خليج السويس فى الفترة من مارس 1988 إلى فبراير 1999. واختيرت المحطات على أساس وقوعها قريبا من المناطق العمرانية والصناعية التى قد تكون مصدرا للتلوث بهذه المعادن. وقد أضهرت النتائج قدرة الطحالب البحرية على امتصاص هذه المعادن والتى تراوحت مستوياتها فى ماء البحر بين 0.105 جزء فى البليون وذلك لمعدن الكروم إلى 20.76 جزء فى البليون لمعدن الزنك. وتدرجت مستويات باقى المعادن بين تلك الدرجتين. أما فى الطحالب البحرية فقد ارتفعت مستويات تلك المعادن كثيرا لتتراوح بين 1.93 جزء فى المليون بالنسبة للكروم إلى 1528.89 جزء فى المليون بالنسبة للحديد. وأظهرت الدراسة قدرة عدد من الطحالب على إمتصاص تركيزات عالية من المعادن الأمر الذى يجعل إستخدامها كمنظف بيئى طبيعى أمرا بينا. وعلى رأس القائمة يظهر طحلب كلادوفوروبسس زونلنجرى الذى امتص من الكروم والحديد والمنجنيز ما هو 70، 112، 306 ضعف الموجود فى ماء البحر على التوالى. أما عناصر الكدميوم والكوبلت والرصاص فقد ساهمت الطحالب الكلسية فى امتصاص ما قيمته 29، 32، 34 ضعف المقاس فى ماء البحر على التوالى. وهذا ما يثبت فاعلية هذه الطحالب كمنظف بيئى للملوثات.