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Accumulation of Cd, Cu, Pb, and Zn in water, sediments, and mangrove crabs (*Sesarma mederi*) in the upper Gulf of Thailand

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ABSTRACT: Mangrove crabs (*Sesarma mederi*) can be used as bioindicators of the environment. This study aimed to estimate the heavy metal content in *S. mederi* in various Thai mangroves and compare them with other studies for international regulations for human consumption. *S. mederi* were obtained from the mangroves of the Chao Phraya, Tha Chin, and Mae Klong rivers. The concentrations of Cd, Cu, and Pb in the rivers were low compared to the marine standards of Thailand and estuarine water elsewhere. The concentrations of Cd and Cu in sediments were rather similar to those in other rivers. The results showed that crabs accumulated metals in the order: Cd > Cu > Pb > Zn. The bioconcentration factor of Cd and Cu was highest in Mae Klong, while Pb and Zn were highest in Chao Phraya. Although metal concentrations in crabs were within the ranges found in other studies, they exceeded the maximum ranges according to standards. Hence as mangrove crabs are highly consumed as traditional and international Thai food, they may be a potential health hazard for human consumers. Consequently, the use of mangrove crab could be an interesting tool for monitoring estuary pollution.

KEYWORDS: bioaccumulation, metals, mangrove ecosystems

INTRODUCTION

Metals are taken up and subsequently accumulated by organisms from natural and contaminated effluents and enter the estuarine ecosystem through direct discharges from coastal communities, ships, rivers and atmospheric deposition, and through land runoff[1]. A large number of metal pollutants derive from industrial and domestic wastes generated especially by the big cities[2–4].

The pollution levels of the aquatic environment by metals can be estimated by analysing water, sediments, and aquatic organisms. A chemical analysis of the water does not provide complete information on the bioavailability of metals present in the environment[5,6]. Hence recent research related to metal pollution in aquatic systems has focused on the use of biological indicators or bioindicators. Bioindicators, also called biomonitors, are species sensitive to environmental change, habitat quality or anthropogenic influence, and thus their status can be used to infer the health of the environment or the status of other species living on similar habitat[7]. Aquatic species have large body to accumulate pollutants, and providing appropriate material to use them as bioindicator for an indirect estimation of the concentration of pollution in their living environment[8–10]. One of the crustaceans that absorb better metals and they are easy to spot and collect in large quantities, which makes easier their study compared to other organisms. Aquatic organisms have been used widely as monitors of metal concentration[11–13]. Aquatic organisms are often exposed to a mixture of metals rather than a single element. Metals, such as Cu and Zn, play an important role in cellular metabolism and their body concentrations can be regulated by the organisms. Others, such as Cd and Pb, are toxic even at low concentrations and tend to accumulate in the body of crustaceans[11,14]. At present, considerable evidence exists to show that certain metals are a threat to human health when consumed even at trace levels[15].

Levels and accumulations of metals in marine organisms usually fluctuate as the change of some seasonal factors such as seasonal dietary, temperature, and salinity[16]. The salinity of water appears to influence the uptake of metals as higher levels of metals are found during the flooding season when salinity is lower[17]. The accumulations of Cd, Cu, Pb, and Zn are likely to vary within organisms[18].

In Thailand, metals contaminate estuarine areas such as the ones of Chao Phraya River (CP), Tha Chin River (TH), and Mae Klong River (MK)[19–21]. The CP, TC, and MK flow through the densely populated central plain of Thailand before discharging into the upper Gulf of Thailand. Because of its nutrient-rich, shallow waters, and confined nature, these ecosystems are especially vulnerable to human activities. The principal cause of the declining of fishery production in the Gulf of Thailand is overfishing. However, Detrimental effects of pollution on these ecosystems are believed to have an increased significant amount of metals[22]. The rapidly increasing population with associated industrialization and economic development in the coastal areas, combined with insufficient environmental protection measures, may have led to elevated levels of metal pollution in Thailand[23]. A study on metal pollution in the upper Gulf of Thailand indicated that the accumulations of Pb, Zn, Cu, and Cd in the waters of river mouth vicinities were significant, which may have a long term impact on the aquatic environment through precipitation of metals to the bottom sediments and bioaccumulation and biomagnification of metals in various food chains[24].

In this study, the accumulations of Cd, Cu, Pb, and Zn in mangrove crabs (*Sesarma mederi*), from CP, MK, and TC were studied. *S. mederi* is a detritivore decomposing plant and animal parts as well as organic faecal matter. Crabs are common in the diet of local inhabitants and its fishery has a considerable economic importance[25]. The concentrations of metals in *S. mederi* may diagnose the degree of contamination of metals in the coastal zone when compared the concentrations of metals between the river mounts along a coastal area. Moreover, the results may be compared with those of similar studies and with the existing international regulations related to the content of metals in crustaceans for human consumption.

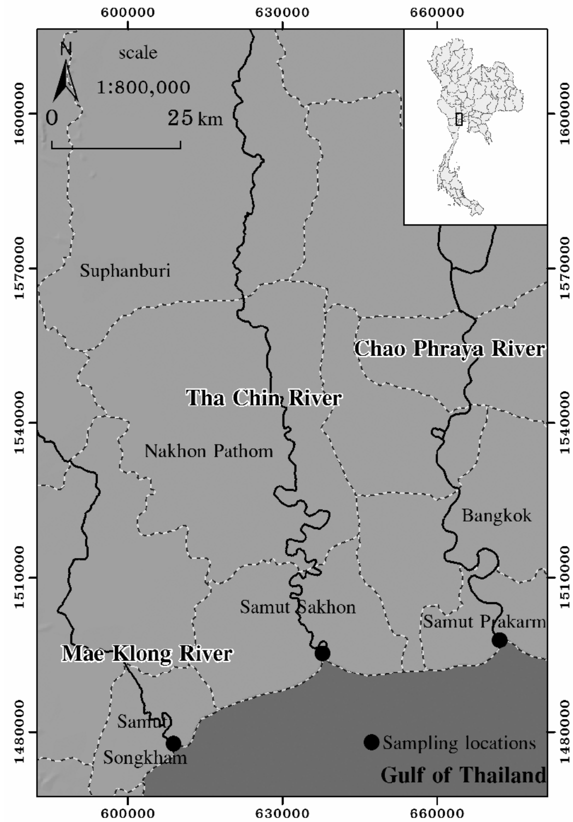

Fig. 1 The Chao Phraya Delta comprises 3 major river basins, the Chao Phraya (CP), Tha Chin (TC), and Mae Klong (MK).

MATERIALS AND METHODS

The Gulf of Thailand extends from the shallow western part of the South China Sea over 750 km to the north between the Thai-Malaysian peninsula and Indo-China. The northern boundary is the coast of the central plain of Thailand. The total area of the gulf is about 32 000 km^2 with an average depth of 45 m. Maximum depth in the central part ranges from 70–85 m. The square (100×100 km^2) upper part of the gulf has an average depth of 15 m. The water depth increases gradually from the shallow northern coast, Bangkok bar, to a mean depth of 25 m at its mouth between Hua Hin and Sattahip. The eastern part, with its rock offshore islands, is slightly deeper than the western part. There are 5 rivers entering the northern coast of the upper gulf from west to east: Phetchaburi province, MK, TC, CP and Bang Pakong. In the past, these rivers are the major sources of pollutants in this upper part of the gulf, especially MK, TC, and CP[26].

Collection and preparation of samples

Mangrove crabs were trapped by indigenous crab live traps in the estuary under the mangrove forests of CP, TC, and MK (50 m from the Gulf of Thailand; UTM Zone 47, 679 302 m N 1 494 887 m E, 637 750 m N 1 493 028 m E, and 608 357 m N 1 476 672 m E, Fig. 1). From higher to lower human activity: CP is mainly rice fields, has the highest number of industrial estates, and metropolitan areas, TC has mainly marine frozen food industries, and MK is an agricultural area with agriculture industries. Each river had 3 trapping sites (20 traps per site, 10 m distance from each other), 10 *S. mederi* were trapped randomly in each trapping site in each month in the dry (December 2006, February and April 2007) and wet seasons (January, August, and October 2007). All crabs were washed in running tap water for 5 min. Samples were rinsed twice with deionized water and their fresh weights were recorded. Then, they were separated into tissues and carapaces and dried at 60 °C for 2 days in a hot air oven to a constant weight. Dry weights of tissues and carapaces were determined. Corresponding 6 sediments (1 m depth) and 6 estuarine water samples (30 cm depth) were collected randomly at each trapping area in each month.

RESULTS

Metals in water and sediment

Dry tissues and carapace samples were ground with a mortar and pestle. 0.5 g dry weight of crab samples was digested with 5 ml nitric acid (69% HNO_3, BDH) and impurities were removed by filtration[27]. Soil samples were ground and passed through a 2 mm nylon sieve. 0.5 g of soil sample was digested with 5 ml nitric acid (69% HNO_3, BDH) and impurities removed by filtration[27]. Water samples were acid-digested with 10 ml of 65% HNO_3 (analytical-reagent grade) and evaporated until the total volume reached to approximately 1 ml. Then the mixture was digested using 5 ml of diluted HNO_3 (1:49, V/V) for 12 h at room temperature[12]. The absorption wavelength and detection limit were 228.8 nm and 0.02 µg/g for Cd, 283.3 nm and 0.05 µg/g for Pb, 324.8 nm and 0.2 µg/g for Cu, 248.3 nm and 0.05 µg/g for Zn. The recovery tests for standards (analytical grade, E. Merck) were 99.8% for Cd, 99.4% for Pb, 98% for Cu and 99.4% for Zn. After digestion, Cd, Cu, Pb, and Zn concentrations in tissue, carapace, sediment, and water samples were measured by a flame atomic absorption spectrophotometer (FAAS; Variance SpectrAA 55B). To assess the analytical precision, three replicates of analytical samples, an appropriate standard reference material and a regent blank were performed in each analytical batch. FAAS was also verified by the laboratory of the Department of Primary Industries and Mines, the laboratory of the Department of Soil Science, Ministry of Agriculture and Cooperatives, and the Central Instrument Facilities, Faculty of Science, Mahidol University.

The dry weight of the biota-sediment accumulation factor (BSAF, i.e., the concentration of a particular metal in tissue per concentration of such metal in sediment, also called enrichment ratio) of tissues in comparison with element concentrations in the sediments was assumed to equal to 20% of wet weight, a conversion derived from the data of Williams and Robins[12]. BSAF was calculated as: (element concentration in tissue or carapace)/(element concentration in sediment). Data were expressed as means with standard deviation. One way ANOVA (SPSS 17.00 computer software) was used to test the effect of metals on growth and metal contents in crabs and soils. If the F-value showed significant differences ($p < 0.05$), means were compared with least significant difference method (LSD).

The mean water concentrations of Cd, Cu, Pb, and Zn in waters of CP, TC, and MK were low when compared to the water quality parameters at the river mouths of the inner Gulf of Thailand in 1983 (Table 1)[28]. All metal pollutants obtained the highest values during the dry season (Table 1). The average water pH values of CP, TC, and MK were not acidic. TC had the highest concentrations of Cd, Pb, and Zn ($p < 0.05$) with the highest values in water pH and salinity.

The mean concentrations in water of Cd, Cu, Pb, and Zn were higher in the dry season for all study areas with the exception of MK. While Cd was different in CP and TC ($p < 0.05$), Cu was different in CP ($p < 0.05$), and Pb and Zn were different in TC ($p < 0.05$) between dry and wet seasons due to the effect of rain and flooding during the wet season (Table 1).

The mean concentrations of Cd and Cu in sediments of CP, TC, and MK were similar to those concentrations in water, while Pb and Zn concentrations were higher than those of the water (Table 1). Cd was highest in TC in wet season, Cu was highest in CP in dry season, Pb was highest in MK in wet season and Zn was highest in MK in dry season. The mean sediment concentrations of Cd, Cu, Pb, and Zn were not different between dry and wet seasons, except for Cu in CP, which was higher in the dry season ($p > 0.05$). Cu source can be derived from cities and industrial activities in CP and reduced by flood during the wet season.

Metals in mangrove crabs

The highest concentrations of Cd, Cu, and Pb were in TC, while Zn was highest in CP. Cd and Zn were mostly concentrated in the body, while Cu was highest in tissue, and Pb was highest in carapace (Table 2). Cd, Cu, and Pb concentrations were highest in the wet season (when there was low salinity).

Table 1 Metal concentrations in water and sediment in dry and wet seasons in Chao Phraya (CP), Tha Chin (TC), and Mae Klong (MK) basins.

Site	pH	Salinity	Metals (μg/l for water, μg/g dry weight for sediment)							
			Cd		Cu		Pb		Zn	
			Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Thailand†	7–8.5	–	$\leqslant 5$		$\leqslant 8$		$\leqslant 8.5$		$\leqslant 50$	
Blank	–	–	ND	ND	ND	ND	ND	ND	ND	ND
Water										
CP	7.2 ± 0.4	2.89 ± 0.00	0.03 ± 0.01^{aA}	0.01 ± 0.00^{B}	0.81 ± 0.12^{aA}	0.57 ± 0.23^{B}	0.43 ± 0.37^{a}	0.33 ± 0.26	0.19 ± 0.15^{a}	0.15 ± 0.08^{a}
TC	9.9 ± 7.7	0.16 ± 0.08	0.03 ± 0.02^{aA}	0.01 ± 0.01^{B}	0.46 ± 0.29^{b}	0.45 ± 0.11	0.43 ± 0.34^{aA}	0.15 ± 0.11^{B}	0.53 ± 0.14^{bA}	0.36 ± 0.24^{bB}
MK	8.2 ± 0.8	0.08 ± 0.12	0.02 ± 0.01^{b}	ND	ND	ND	0.08 ± 0.01^{b}	0.08 ± 0.01	0.19 ± 0.07^{a}	0.16 ± 0.05^{a}
Sediment										
CP	NA	NA	0.02 ± 0.01	0.02 ± 0.01	0.89 ± 0.64^{A}	0.43 ± 0.02^{B}	0.64 ± 0.25^{a}	0.77 ± 0.18^{a}	1.46 ± 0.01	1.33 ± 0.10
TC	NA	NA	0.02 ± 0.01	0.02 ± 0.01	0.75 ± 0.30^{A}	0.33 ± 0.10^{B}	1.12 ± 0.04^{b}	1.19 ± 0.07^{b}	1.60 ± 0.35	1.38 ± 0.86
MK	NA	NA	ND	ND	0.61 ± 0.45	0.49 ± 0.08	1.32 ± 0.33^{bA}	1.63 ± 0.25^{cB}	1.99 ± 0.95	1.78 ± 0.83

Data with different letter (a, b, c) in the same column and same item, or (A, B) in the same row and same metal indicate a significant difference at 5% level by LSD test.

† Thailand water standards [29].

ND = non-detectable; NA = not analysed.

Table 2 Metal concentrations in tissues, carapacesm and whole body of *S. mederi* in the dry and wet seasons of 2007 in Chao Phraya (CP), Tha Chin (TC), and Mae Klong (MK) basins.

Crab part	Metals (μg/g dry weight)							
	Cd		Cu		Pb		Zn	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Blank	ND	ND	ND	ND	ND	ND	ND	ND
Whole								
CP	3.08 ± 0.47^{a}	3.74 ± 0.50^{a}	1.48 ± 0.85	1.86 ± 0.96	6.10 ± 3.11^{ab}	5.41 ± 2.43^{ab}	4.93 ± 0.71^{aA}	3.83 ± 0.43^{aB}
TC	3.95 ± 0.66^{b}	4.49 ± 1.21^{b}	1.74 ± 0.75	2.10 ± 0.83	7.88 ± 5.35^{a}	7.23 ± 6.26^{a}	4.58 ± 0.36^{aA}	3.63 ± 1.14^{aB}
MK	3.92 ± 0.78^{b}	3.56 ± 1.04^{a}	1.30 ± 0.79	1.71 ± 0.87	3.27 ± 1.44^{b}	2.51 ± 2.20^{b}	4.00 ± 0.51^{bA}	0.65 ± 0.20^{bB}
Tissue								
CP	1.46 ± 0.34	1.48 ± 0.30	1.74 ± 0.35^{A}	2.26 ± 0.25^{B}	2.04 ± 1.01^{a}	1.92 ± 1.05^{a}	4.57 ± 0.60^{aA}	3.92 ± 0.45^{B}
TC	1.58 ± 0.42	1.54 ± 0.19	1.97 ± 0.29^{A}	2.26 ± 0.14^{B}	0.94 ± 0.89^{b}	0.73 ± 0.27^{b}	4.35 ± 0.22^{abA}	3.60 ± 0.34^{B}
MK	1.35 ± 0.49	1.35 ± 0.33	1.91 ± 0.32	2.09 ± 0.25	0.54 ± 0.25^{b}	0.35 ± 0.09^{b}	3.72 ± 0.46^{b}	3.80 ± 0.50
Carapace								
CP	2.43 ± 0.30^{a}	2.38 ± 0.32^{a}	0.41 ± 0.08	0.52 ± 0.14	6.99 ± 3.12^{a}	6.29 ± 3.07^{a}	0.51 ± 0.05^{aA}	0.40 ± 0.12^{B}
TC	2.92 ± 0.55^{a}	3.01 ± 0.99^{b}	0.45 ± 0.17	0.53 ± 0.17	7.21 ± 5.44^{a}	9.33 ± 7.76^{a}	0.39 ± 0.13^{b}	0.39 ± 0.09
MK	1.35 ± 0.46^{b}	1.08 ± 0.46^{c}	0.40 ± 0.14	0.50 ± 0.19	2.84 ± 1.50^{b}	2.18 ± 2.18^{b}	0.37 ± 0.09^{b}	0.38 ± 0.11

Data with different letter (a, b, c) in the same column and same item, or (A, B) in the same row and same metal indicate a significant difference at 5% level by LSD test.

ND = non-detectable.

Biota-sediment accumulation of metals

To evaluate the efficiency of BSAF in *S. mederi* was determined (Fig. 2). The metals that crabs accumulated in greatest amounts in its body were Cd, with the highest factor of BSAF of 353 in MK, 225 in CP, and 211 in TC, respectively.

DISCUSSION

The mean water concentrations in waters of CP, TC, and MK were also relatively low when compared with the marine water standards of Thailand [29] and other estuaries in the world [5,30–35]. All study areas were located in rivers close to the sea. Hence there was a great decrease in the metal levels due to seawater, which, apart from the dilution effect (seawater has a low metal content), causes precipitation of large amounts of metals into the sediments as a result of the increased pH and salinity of the water [5,35]. In wet season the rain and flood dilute the metals and raise them to the sea.

The mean concentrations of Cd and Cu in sediments were higher than those of the water because the dilution effect can cause precipitation of large amounts of metals into the sediments as a result of the increased pH and salinity of the water when the input

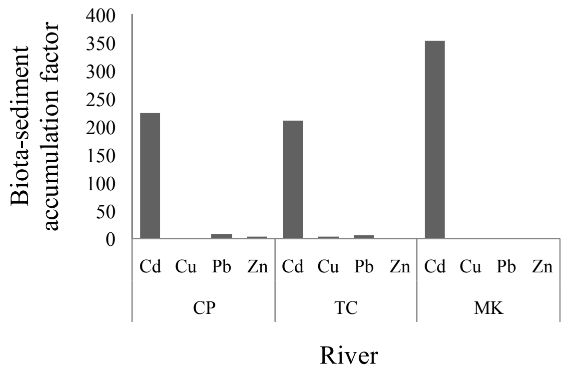

Fig. 2 BSAF (biota-sediment accumulation factor) of mangrove crab (*S. mederi*) in the Upper Gulf of Thailand. CP: Chao Phraya; TC: Tha Chin; MK: Mae Klong.

of water was decrease during the dry season[5]. The metal concentrations were not significantly different between dry and wet seasons in MK due to the effect of a dam that controls the water level in the river; most metals were deposited in the sediment under the water. The water of MK runs through the areas known for their Pb mines since historical times. Mining activities have left a large quantity of tailings, from which metal-rich and eroded materials are washed into the rivers and deposited in the MK sediments[36].

The levels of metals recorded in the tissues of biota collected in the field varied among organisms. The metal accumulation was influences by prey selection[35]. In this study, BSAF were low for Cu, Pb, and Zn, but were high for Cd in all rivers as found by Ahmed et al[37]. Jara-Marini et al[38] concluded that metals were not positively transferred through entire food web. Only specific organisms, such as filter feeders as *S. mederi*, showed signs of greater accumulation of Cd. Cd and Ca are uptake by an energy-requiring pump in the epithelial cell membrane and then accumulation in the carapace or other part that have high concentration of Ca[11,39]. This result was similar to the studies on amphipods (*Orchestia gammarellus*) by Rainbow et al[40] and Rainbow and Kwan[41], which found that decreases in salinity produced predictable increases in metal uptake rate. This result was different from the study in *Palaemon elegans* and *Palaemonetes varians* by Nugegoda and Rainbow[42,43] that decreases in salinity could decrease concentration of metals. This is similar to the study by Xiaobo et al[12] in molluscs (*Onchidium struma*) that Cu is a cofactor for regulating the activity of Cu-dependent enzymes[12,44] and an essential component required for the synthesis of haemocyanin[45]. These results could be linked to the metal sequestration and detoxification by metallothionein proteins in the carapace. In general, metals undergo detoxification in the hepatopancreas and are subsequently excreted as granules from the epithelium of the hepatopancreas. As the main tissue for metal detoxification, the bioconcentration in the hepatopancreas could be the reflection of the whole body metal enrichment[46].

Several studies have previously reported metal accumulations in crabs from different geographical areas (Table 3). Montes Nieto et al[47] detected metal accumulation in the gill of *Carcinus maenas* in Spain and they found a correlation between metal accumulation and degree of industrialization. Firat et al[48] found high concentrations of metals in shrimps (*Penaeus semisulcatus*) in Iskenderun Bay, Turkey, mainly caused by the wastewater drainage from the city nearby. This excessive metal concentration in river mounts of the upper gulf of Thailand may be caused by agricultural and industrial wastewater coming from upstream areas together with municipal wastewater from the cities nearby[49].

It is important to detect metal concentrations in marine organisms because they allow determine whether these aquatic organisms may constitute a health hazard for consumers[12]. According to the current seafood standards regulated by the Food Standards Australia New Zealand[50], the maximum allowable limits of Cu, Pb, and Zn are 100, 1.5, and 150 µg/g wet weight, respectively. However, no upper limits for Cd are specified by FSANZ[50]. The Hygienic Standard for Fresh and Frozen Marine Products of Animal Origin (GB 2733-2005) in China specifies the maximum levels of Cd in 0.5 µg/g wet weight and of Pb in 0.5 µg/g wet weight. In Thailand (TH), Environmental Health Division[28] only specifies the maximum levels of Cd (2 µg/g wet weight) and Pb (0.5 µg/g wet weight)[12]. Hence based on the standard of FSANZ, GB 2733-2005 and TH, the accumulation of Pb the whole body and carapace of *S. mederi* in all rivers, and tissue in CP were higher than these standards, while tissue in TC and MK were higher than GB 2733-2005 and TH. Cd in the whole body was higher than these standards, while tissue and carapace were higher than FSANZ but lower than TH. All parts of *S. mederi* were lower than these standards.

Cu, Pb, and Zn in all rivers obtained BSAF ratios under 10, which may be due to lesser bioavailability of these metals as compared to other metals. The BSAF of Cd and Cu were higher than in common barnacle (*Balanus balanoides*), while Zn was lower than the study made by Morillo et al[5]. If compared between the river sites, the BSAF of Cd was highest

Table 3 Selected references of metal concentrations (µg/g dry weight) in crab species from different geographical areas (mean values and ranges).

Site	Species	Cd	Cu	Pd	Zn	Reference
Chao Phraya River mount, Thailand	*Sesarma mederi*					This study
	Tissue (range)	1.19–1.55	64.78–113.97	0.47–13.43	169.11–259.5	
	Carapace (range)	1.98–2.9	17.71–37.0	0.3–8.7	14.34–28.8	
Tha Chin River mount, Thailand	*S. mederi*					This study
	Tissue (range)	1.26–1.7	83.91–123.53	0.24–1.26	162.82–223.76	
	Carapace (range)	2.08–5.03	12.57–39.2	2.1–21.07	14.36–33.41	
Mae Klong River mount, Thailand	*S. mederi*					This study
	Tissue (range)	1.22–3.11	89.63–105.12	0.15–0.84	177.2–231.39	
	Carapace (range)	0.61–2.14	11.17–42.12	0.26–8.23	14.86–24.18	
Huelva Estuary, SW Spain	*Carcinus maenas*					Montes Nieto et al [47]
	Gill	–	66 ± 10	17.2 ± 6.1	118 ± 22	
Cádiz Bay	Gill	–	33.4 ± 3.5	1.68 ± 0.53	32.5 ± 6.2	
SE Gulf of California	*Callinectes arcuatus*					Jara-Marini et al [38]
	Gill	0.10 ± 0.01	60.3 ± 5.4	0.22 ± 0.06	39.4 ± 1.4	
Ojo River, Nigeria	*Callinectes amnicola*					Olusegun et al [18]
	Abdomen (male)	0.39	–	5.27	9.33	
	(female)	0.35	–	3.28	12.92	
	Thorax (male)	0.32	–	3.92	8.31	
	(female)	0.35	–	2.87	9.83	
	Tissue (male)	0.22	–	ND	15.75	
	(female)	0.17	–	0.83	16.03	
	Range	0.17–0.39	–	ND–5.27	8.31–16.03	
Iskenderun Bay, Turkey	*Penaeus semisulcatus*					Firat et al [48]
	Muscle	25.4 ± 7.8	78 ± 12	–	32.5 ± 7.0	
	(range)	(16–37)	(60.8–96.2)		(25.1–45.7)	
	Gill	75.5 ± 8.8	827 ± 93	–	698 ± 118	
	(range)	(61.2–88.2)	(677.4–908.3)		(553.3–840.0)	
	Hepatopancreas	111 ± 23	935 ± 50	–	805 ± 103	
	(range)	(90.3–149.6)	(870.7–1000.1)		(846.3–950.0)	
Pearl River Estuary, S China	*Portunus pelagicus*	0.80 ± 0.51	26 ± 24	10.18 ± 0.06	16.3 ± 2.9	Ip et al [51]
	(range)	(0.2–1.61)	(16.3–41.8)	(0.04–0.23)	(12.2–19.9)	
Eerste River, S Africa	*Potamonautes perlatus*					Reinecke et al [52]
	Whole (up stream)	3.4 ± 2.8	–	16 ± 19	–	
	(down stream)	5.0 ± 6.3	–	20 ± 32	–	

at MK followed by CP, and TC. We conclude that accumulation of Cd in *S. mederi*, when compared to other organisms, is a good tool for monitoring metals even if the water has low concentration of these metals.

CONCLUSIONS

This study provides information related to accumulation of Cd, Cu, Pb, and Zn in waters, sediments, and *S. mederi* in CP, TC, and MK of the upper gulf of Thailand. The results show that mangrove crabs accumulated metals in this ranking order: Cd > Cu > Pb > Zn. The variation in metal concentration in waters and sediments depends on the activities of the human communities in the upper stream such as mining, industries and urbanization. Accumulation of Cd in *S. mederi* is a good tool for monitoring metals when compared to other organisms. Based on the results obtained, it was noted that the Cd, Cu, Pb, and Zn are within the ranges found by other authors, but exceeded the maximum ranges of FSANZ and GB 2733-2005. As study species in the upper Gulf of Thailand are highly consumed as traditional food and it becomes famous as international Thai food, the relatively high accumulation of these metals detected may be a potential health hazard for its human consumers.

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