Bull Environ Contam Toxicol (2011) 87:282–286
DOI 10.1007/s00128-011-0363-3

Comparison of Metal Concentrations in Tissues of Blue Crab, *Callinectes sapidus* from Mediterranean Lagoons

Cengiz Mutlu · Mustafa Türkmen · Aysun Türkmen · Yalçın Tepe

Received: 1 April 2011 / Accepted: 1 July 2011 / Published online: 14 July 2011

Abstract This study was performed to investigate the metal concentrations in muscle and gill of blue crab, *Callinectes sapidus* from Dörtyol Lake, Akyatan Lagoon, Paradeniz Lagoon and Çamlık Lagoon from the north-eastern coastal area of Mediterranean Sea. So, the levels of cadmium, chromium, copper, iron, manganese, nickel, aluminum and zinc in tissues of specimens from the lagoons were determined by inductively coupled plasma optical emission spectrometer. The metal concentrations found in muscle tissue varied for Cd: 0.03–0.08, Cr: 0.05–0.13, Cu: 5.38–11.7, Fe: 21.1–38.2, Mn: 0.15–2.98, Ni: 0.24–0.45, Zn: 13.9–20.1 and Al: 1.2–13.7 mg/kg wet weight. Iron showed the highest levels in both tissues, and generally followed by zinc except gills. On the other hand, cadmium showed the lowest levels from all sites. Followed cadmium; chromium had the second lowest levels. The differences between mean metal concentrations from different sampling sites were statistically significant. Regional changes in metal concentration were observed in the tissues of the crabs, but these variations may not influence consumption advisories.

Keywords Metals · Blue crab · Mediterranean lagoons · Tissues

C. Mutlu · M. Türkmen (✉) · Y. Tepe
Department of Biology, Faculty of Science and Arts, Giresun University, 28049 Giresun, Turkey
e-mail: mturkmen65@hotmail.com

A. Türkmen
Department of Chemistry, Faculty of Science and Arts, Giresun University, 28049 Giresun, Turkey

Because economically important sea foods such as fish, crabs, oysters and mussels accumulate contaminants from the aquatic environments, they have been extensively used in the assessment of aquatic pollution and monitoring studies (Ismail et al. 1991; Snyman 1996; Türkmen et al. 2005, 2006; Minganti et al. 2010; Uysal 2011). The coastal areas such as lagoon and bay in seas are important grounds for vital activities of valuable aquatic organisms such as crabs, fish, oysters and muscles. Because human activities directly affect these areas, contamination studies frequently should be made in these areas. Having economic importance for fisheries, sampling sites are situated in the northern east part of the Mediterranean Sea. Sewage wastes and ship maintenance works are dumped directly into the sea without any treatment. Industries, in this region of the Mediterranean Sea, are also expanding; most of these industries such as cement factory, textiles, tin, iron and rubbish treatment, food conserves, oil refinery, phosphate loading activities etc. use sea or river systems to dump their effluent. In addition, the predominant current system indicates that pollution from external source is highly possible and consequently, local practices are not the only potential source of pollution. Wastewater collection and disposal systems have been planned and constructed in some areas, but these are still not sufficient in some other areas due to primarily limited budget (Türkmen et al. 2006). Intense pollution in the sea has inevitably increased the levels of metals in the water. There is lack of information about the history and current situation of pollution along the Mediterranean Sea. Therefore, it is very important to determine the levels of metals in commercial species in order to evaluate the possible risk of sea food consumption for human health. Crabs may be especially sensitive to pollution and other types of habitat degradation because they reside in bottom sediments where chemical contaminants may accumulate. The main objective of this study was to determine the levels of Cd, Cu, Cr, Zn, Fe, Ni, Al and Mn in the muscle and gill of blue crab, *Callinectes sapidus*, from the coastal lagoons of Mediterranean Sea and to assess whether crabs from these sites are acceptable for human consumption.

Materials and Methods

Sampling sites were Dörtyol Lake, DL (36°52' N, 36° 7' E), Akyatan Lagoon, AL (36°37' N, 35°15' E), Paradeniz Lagoon, PL (36°17' N, 34° 0' E) and Çamlık Lagoon, ÇL (36°43' N, 35°37' E) from Mediterranean coastal area of Turkey. Totally fifty blue crab samples (15 from DL, 15 from AL, 10 from PL and 10 from ÇL) were captured with landing nets from sampling sites between September 2006 and May 2007. Samples placed on ice, brought to laboratory and then frozen at −20°C until dissection. Total size and weight of the samples were measured to the nearest millimeter and gram before dissection. The mean weights and carapax widths were 143.4 ± 3.7 g and 80.5 ± 0.9 mm for site GL, 213.1 ± 9.0 g and 87.1 ± 1.4 mm for site AL, 126.7 ± 5.3 g and 65.8 ± 1.3 mm for site PL, and 91.6 ± 4.07 g and 63.5 ± 1.4 mm for site ÇL respectively. The carapace of samples was removed, and muscles and gills from each crab were dissected, washed with distilled water, packed in polyethylene bags and stored at −18°C prior to analysis.

Dissected tissues were homogenized and digested with 10 mL of nitric acid (analytical grade) in Teflon vessels in microwave oven (CEM MARS-5 Closed Vessel Microwave Digestion System) using the following microwave digestion program; pressure 200 psi, ramp time 25 min., temperature 210°C, maximum power 300 W, hold time 10 min. After cooling, residue was transferred to 25 mL volumetric flasks and diluted to level with deionized water. Before analysis, the samples were filtered through a 0.45 μm filter. Sample blanks were prepared in the laboratory in a similar manner to the field samples. All samples were analyzed three times for target heavy metals by inductively coupled plasma optical emission spectrometer (ICP-OES, VARIAN VISTA-MPX OES). Detection limits were 0.001 for Cd, 0.002 for Cr and Mn, 0.02 for Cu and Ni, 0.3 for Fe, 0.01 for Al and 0.2 for Zn. All metal concentrations were determined on wet weight basis as μg g^{-1}. Standard solutions were prepared from stock solutions (Merck, multi element standard). A Dorm-2 certified dogfish tissue was used as the calibration verification standard (Table 1). Extractions and analyses of tissues were performed in the Food Quality Control Laboratory of Hatay. One way ANOVA and Tukey multiple range test were performed to test the differences of the metal levels among sites. Possibilities less than 0.05 were considered statistically significant ($p < 0.05$). All statistical calculations were performed with SPSS 13.0 for windows.

Results and Discussion

The mean concentrations of cadminum, chromium, copper, iron, manganese, nickel, zinc and aluminum in tissues of blue crab, *Callinectes sapidus*, from lagoons in south eastern Mediterranean coastal area were given in Table 2. A total of 50 crabs were analyzed in this study. Iron showed the highest levels in both tissues, and generally followed by zinc except gills. On the other hand, cadmium showed the lowest levels from all sites. Followed cadmium; chromium had the second lowest levels, generally in agreement with the results of many researchers (Tepe et al. 2008; Türkmen et al. 2009, 2010). Except Zinc, all metal concentrations in gills from all sites were higher than muscles. This situation is in agreement with the results of many researchers (Bjerregaard and Depledge 2002; Thawley et al. 2004).

The differences between mean metal concentrations from different sampling sites were statistically significant, except Cr, Ni and Al ($p < 0.05$). On the other hand, the differences between tissues for same metal were statistically significant in all sites for Mn and Al, in sites DL, AL and ÇL for Cr, in site ÇL for Cu, in sites DL, AL and PL for Fe, in sites DL and AL for Ni, in sites AL and PL for Zn ($p < 0.05$). Table 3 shows the comparison the data of the present study with that from elsewhere. Although cadmium concentrations measured in the muscles of blue crab in our study were lower than those reported for İskenderun Bay (Türkmen et al. 2006), were higher than

Table 1 Certified and observed values of metals in CRM, Dorm-2 (dogfish muscle) from the NRC (means ± SE, mg kg^{-1} dry wt)

Value	Cd	Cu	Cr	Fe	Ni	Mn	Al	Zn
Certified SE	0.043	2.34	34.7	142	19.4	3.66	10.9	26.6
	0.008	0.16	5.5	10	3.1	0.34	1.7	2.3
Observed SE	0.048	2.43	32.9	139	20.1	3.55	10.5	25.8
	0.012	0.22	6.01	11.6	3.34	0.46	1.51	2.81
Recovery (%)	111	104	95	98	104	97	96	97

[a] Each value is the average of nine determinations

Table 2 The comparison of the mean metal concentrations with SE of *C. sapidus* tissues from different sites (μg g^{-1} wet weight)

Metal/tissue	Sampling sites			
	Dörtyol Lk.*	Akyatan Lg.	Paradeniz Lg.	Çamlık Lg.
Cadmium				
Muscle	0.03 ± 0.01>^{a,x}	0.04 ± 0.01^{a,x}	0.03 ± 0.01>^{a,x}	0.08 ± 0.02^{b,x}
Gill	0.04 ± 0.01^{a,x}	0.05 ± 0.01^{a,x}	0.04 ± 0.01^{a,x}	0.10 ± 0.02^{b,x}
Chromium				
Muscle	0.07 ± 0.01^{a,x}	0.13 ± 0.06^{a,x}	0.06 ± 0.01^{a,x}	0.05 ± 0.02^{a,x}
Gill	0.49 ± 0.15^{ab,y}	0.46 ± 0.10^{ab,y}	0.08 ± 0.03^{a,x}	0.61 ± 0.12^{b,y}
Copper				
Muscle	11.7 ± 1.40^{b,x}	6.28 ± 0.98^{a,x}	5.38 ± 0.71^{a,x}	8.44 ± 0.77^{ab,x}
Gill	13.6 ± 0.84^{b,x}	10.2 ± 1.34^{ab,x}	7.68 ± 1.11^{a,x}	24.5 ± 2.09^{c,y}
Iron				
Muscle	25.5 ± 2.26^{ab,x}	33.6 ± 2.90^{bc,x}	21.1 ± 2.06^{a,x}	38.2 ± 4.03^{c,x}
Gill	66.4 ± 10.5^{a,y}	117 ± 12.3^{b,y}	58.4 ± 8.27^{a,y}	170 ± 18.4^{c,x}
Manganese				
Muscle	2.98 ± 0.63^{a,x}	1.48 ± 0.51^{ab,x}	0.15 ± 0.05^{b,x}	0.94 ± 0.12^{b,x}
Gill	12.8 ± 2.16^{a,y}	17.7 ± 4.12^{a,y}	2.02 ± 0.47^{a,y}	11.78 ± 2.79^{a,y}
Nickel				
Muscle	0.43 ± 0.11^{a,x}	0.45 ± 0.17^{a,x}	0.24 ± 0.12^{a,x}	0.39 ± 0.16^{a,x}
Gill	1.96 ± 0.56^{a,y}	1.53 ± 0.29^{ab,y}	0.46 ± 0.08^{b,x}	1.34 ± 0.18^{ab,x}
Zinc				
Muscle	18.1 ± 1.02^{ab,x}	16.9 ± 1.57^{ab,x}	13.9 ± 0.93^{a,x}	20.1 ± 1.42^{b,x}
Gill	11.5 ± 0.85^{a,x}	8.15 ± 0.52^{b,y}	7.69 ± 0.87^{b,y}	9.48 ± 0.67^{ab,x}
Aluminum				
Muscle	1.20 ± 0.18^{a,x}	13.7 ± 3.41^{a,x}	1.31 ± 0.12^{a,x}	5.21 ± 0.55^{a,x}
Gill	6.05 ± 1.17^{a,y}	72.4 ± 14.9^{b,y}	10.5 ± 3.79^{a,y}	77.1 ± 11.9^{b,y}

Horizontally letters a, b and c show differences among sites in the same tissues, vertically x and y show differences between tissues for same metal. Within columns, means with the same letter are not significant, $p > 0.05$

* *Lk.* Lake, *Lg.* Lagoon

those reported by Mortimer (1999), and for both tissues, agreed well with the findings presented by Bjerregaard and Depledge (2002) and Thawley et al. (2004). Our chromium findings for both tissues were lower than those reported for Runaway Bay (Mortimer 1999), İskenderun Bay (Türkmen et al. 2006) and Ojo Rivers Lagos (Olowu et al. 2010). Copper levels obtained for muscles in this study were lower than those reported for Runaway Bay (Mortimer 1999) and River Aponwe (Falusi and Olanipekun 2007), but were higher than those reported for İskenderun Bay (Türkmen et al. 2006) and Ojo Rivers Lagos (Olowu et al. 2010). On the other hand, our findings for both tissues were in agreement with ones reported for Helnæs Bugt (Bjerregaard and Depledge 2002). The levels of iron obtained for muscles from this study were higher than those reported for Runaway Bay (Mortimer 1999) Helnæs Bugt (Bjerregaard and Depledge 2002) and İskenderun Bay (Türkmen et al. 2006), but for gills were lower than Helnæs Bugt. Manganese levels from this study were lower than those reported for Helnæs Bugt, İskenderun Bay and River Aponwe (Bjerregaard and Depledge 2002; Türkmen et al. 2006; Falusi and Olanipekun 2007), but were agreement with levels presented for sand crab muscles by Mortimer (1999). Nickel levels of this study were lower than those reported for İskenderun Bay and River Aponwe (Türkmen et al. 2006; Falusi and Olanipekun 2007), but higher than those presented for sand crab muscles by Mortimer (1999). Our zinc findings were lower than those reported by Mortimer (1999), Bjerregaard and Depledge (2002) and Thawley et al. (2004), but were higher than those reported by Falusi and Olanipekun (2007) and Olowu et al. 2010). Aluminum finding of this study were in agreement with values presented for İskenderun Bay (Türkmen et al. 2006).

The present study is the first for blue crabs in these areas and supply valuable information about metal contents in tissues of the crabs from target sites and indirectly indicate the environmental contamination of the lagoons. Moreover, these results can also be used to understand the chemical quality of crabs and to evaluate the possible risk associated with their consumption. Based on the analyzed samples, metal concentrations found in the muscles of blue crabs were not heavily burdened with metals, and the concentrations were below the legal values for fish and fishery

Table 3 Comparison of the mean metal concentrations in *C. sapidus* with results taken from the other studies (μg g^{-1})

References/metals	Cd	Cr	Cu	Fe	Mn	Ni	Zn	Al
Mortimer and Cox (1999)								
Muscle	<0.001	0.095–0.736	15.8–28.9	12.1–23.2	1.20–2.80	0.10–0.30	63.1–83.4	–
Whole carab	<0.001	0.924–2.59	55.6–78.0	3020–4870	44.7–60.1	8.90–26.8	49.0–63.5	–
Bjerregaard and Depledge (2002)								
Muscle	0.002–0.006	–	7.3–16	14–17	2.5–6.3	–	51–52	–
Gill	0.05–0.06	–	12–16	194–202	15–32	–	9.3–9.4	–
Thawley et al. (2004)								
Muscle	0.06–0.11	–	–	–	–	–	51.3–391	–
Gill	0.05–0.17	–	–	–	–	–	31.4–214	–
Türkmen et al. (2006)								
Muscle	0.20–0.55	0.59–1.69	0.74–2.24	8.87–18.8	1.30–3.10	0.66–1.59	3.20–8.03	1.23–17.56
Falusi and Olanipekun (2007)								
Different tissues	0.06–0.08	–	27.3–29.1		14.8–15.2	1.56–1.75	4.89–5.0	–
Ayejuyo et al. (2009)								
Different tissues	0.23–0.75	0.47–0.67	–	–	–	–	8.31–16.2	–
Olowu et al. (2010)								
Different tissues	0.084–4.00	0.031–30.03	0.033–2.75	–			0.024–6.06	–
This study								
Muscle	0.03–0.08	0.05–0.13	5.38–11.7	21.1–38.2	0.15–2.98	0.24–0.45	13.9–20.1	1.2–13.7
Gill	0.04–0.10	0.08–0.61	7.68–24.5	58.4–170	2.02–17.7	0.46–1.96	7.69–11.5	6.5–77.1
ISSC (2011)	3	12	–	–	–	70	–	–
TKB (2002)	0.1	–	20	–	–	–	50	
Nauen (1983)	0.05–5.5	1.0	10–100	–	–	–	30–100	

products proposed by Nauen (1983). Measured concentrations in μg g^{-1} of Cd (0.03–0.08), Cr (0.05–0.13) and Ni (0.24–0.45) in crab muscles were lower than ISSC (2011) limits for crustacean of 3, 12 and 70 for Cd, Cr and Ni, respectively (Table 3). Turkish acceptable limits for fishery products are reported as Cd: 0.1, Cu: 20 and Zn: 50 μg g^{-1} (TKB 2002). Comparison of our data with the Turkish acceptable limits showed that our values for selected metals are also lower than national guidelines (except the highest value of Cu in gills). Therefore, it can be concluded that these metals have posed no threat for consumption of blue crab muscles for time span of these. However, these results should be confirmed occasionally by running more detailed studies in the bay to better monitor and understand the current situation.

Acknowledgments The authors would like to thank Kamil Yerdoğan and Esra Aslan for their kind assistance analysis in microwave and ICP-OES.

References

Ayejuyo OO, Tovide OO, Moronkola BO (2009) Heavy metal distribution in crab (Callinectes amnicola) living on the shores of Ojo Rivers, Lagos, Nigeria. Environmentalist 29:33–36

Bjerregaard P, Depledge MH (2002) Trace metal concentrations and contents in the tissues of the shore crab *Carcinus maenas*: effects of size and tissue hydration. Mar Biol 141:741–752

Falusi BA, Olanipekun EO (2007) Bioconcentration factors of heavy metals in tropical crab (*Carcinus sp*) from River Aponwe, Ado-Ekiti, Nigeria. J Appl Sci Environ Manag 11:51–54

Ismail A, Badri MA, Ramlan MN (1991) Heavy metal contamination in fiddler crabs (*Uca annulipes*) and hermit crabs (*Clibanarius sp.*) in a coastal area of northern peninsular Malaysia'. Environ Technol 12:923–926

ISSC (2011) Guide for the control of molluscan shellfish, 2007 Revision (Printed March 2009). http://www.issc.org. Accessed 01 March 2011

Minganti V, Drava G, De Pellegrini R, Siccardi C (2010) Trace elements in farmed and wild gilthead seabream, *Sparus aurata*. Mar Pollut Bull 60:2022–2025

Mortimer MR, Cox M (1999) Contaminants in oysters and crabs in a canal adjacent to Lae Drive, runaway bay, Queensland. Report of a study conducted for gold coast city council. Queensland Environmental Protection Agency, Brisbane

Nauen CE (1983) Compilation of legal limits for hazardous substances in fish and fishery products. FAO Fish Circ 764:102

Olowu RA, Ayejuyo OO, Adejoroi A, Adewuyi GO, Osundiya MO, Onwordi CT, Yusuf KA, Owolabi MS (2010) Determination of heavy metals in crab and prawn in Ojo Rivers Lagos, Nigeria. E-J Chem 7:526–530

Snyman RG (1996) The uptake and distribution of selected heavy metals in the freshwater crab, *Potamonautes perlatus* (Milne Edwards), in the Eerste River, Weastern Cape. M.Sc. Thesis, University of Stellenbosch

Tepe Y, Türkmen M, Türkmen A (2008) Assessment of heavy metals in two commercial fish species of four Turkish seas. Environ Monit Assess 146:277–284

Thawley S, Morris S, Vosloo A (2004) Zn and Cd accumulation in *Potamonautes warreni* from sites in the North-West Province of South Africa. Int Cong Ser 1275:180–188

TKB (2002) Fisheries laws and regulations. Ministry of agriculture and rural affairs. Conservation and Control General Management, Ankara

Türkmen A, Türkmen M, Tepe Y, Akyurt İ (2005) Heavy metals in three commercially valuable fish species from İskenderun Bay, Northern East Mediterranean Sea, Turkey. Food Chem 91:167–172

Türkmen A, Türkmen M, Tepe Y, Mazlum Y, Oymael S (2006) Heavy metal levels in Blue Crab (*Callinectes sapidus)* and Mullet (*Mugil cephalus*) in İskenderun Bay (North Eastern Mediterranean, Turkey). B Environ Contam Tox 77:186–193

Türkmen A, Tepe Y, Türkmen M, Mutlu E (2009) Heavy metal contaminants in tissues of the Garfish, *Belone belone* L., 1761, and the Bluefish, *Pomatomus saltatrix* L., 1766, from Turkey Waters. B Environ Contam Tox 82:70–74

Türkmen A, Türkmen M, Tepe Y, Çekiç M (2010) Metals in tissues of fish from Yelkoma Lagoon, northeastern Mediterranean. Environ Monit Assess 168:223–230

Uysal K (2011) Heavy metal in edible portions (muscle and skin) and other organs (gill, liver and intestine) of selected freshwater fish species. Int J Food Prop 14:280–286