Available Online at http://www.journalajst.com

ISSN: 0976-3376

ASIAN JOURNAL OF SCIENCE AND TECHNOLOGY

Asian Journal of Science and Technology
Vol. 08, Issue, 11, pp.6681-6685, November, 2017

RESEARCH ARTICLE

HEAVY METAL CONCENTRATIONS IN SOME BENTHIC ORGANISMS (*CALLINECTES AMNICOLA*) FROM EBRIE LAGOON, ABIDJAN CÔTE D'IVOIRE

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ARTICLE INFO

Article History:
Received 28th August, 2017
Received in revised form
07th September, 2017
Accepted 15th October, 2017
Published online 30th November, 2017

Key words:

Heavy Metals,
Crab *Callinectes amnicola*,
Ebrie lagoon, Abidjan city.

ABSTRACT

Samples of crabs (*Callinectes amnicola*) were collected in six bays of Ebrie lagoon in Abidjan city, and the level of heavy metal (As, Cd, Cr, Pb, Zn) in crabs was investigated using Atomic Absorption Spectrophotometer. The mean concentrations of heavy metals in crabs were follows: Arsenic: 3.09 ± 1.19 mg/kg; cadmium: 0.91 ± 0.24 mg/kg; chromium: 12.95 ± 3.08 mg/kg; lead: 3.80 ± 1.63 mg/kg and zinc: 150.01 ± 39.88 mg/kg. So, metals bioaccumulation in the crabs entire is in Zn > Cr > Pb > As > Cd order. From the analysis point of view, crabs sampled from Ebrie lagoon may be considered unsafe for human consumption, because of the Cr and Pb high concentrations in these organisms, compared to WHO standard for aquatic foods, even if the concentrations of Cd, As and Zn were acceptable according to WHO recommendations. Therefore, special attention should be given to the water quality and bioaccumulation of metals (arsenic, cadmium, chromium, lead and zinc) in crab, *Callinectes amnicola* from Ebrie lagoon.

INTRODUCTION

Heavy metals occur in the environment both as a result of natural processes and as pollutants from human activities (Garcia-Montelongo and *al*, 1994; Jordao and *al*, 2002). Heavy metals are stable and persistent environmental contaminants of aquatic environments. Some metals like Zn, Cu, Fe and Mn, which are required for metabolic activity in organisms, lie in the narrow "window" between their essentiality and toxicity. Other heavy metals like Cd, As, Cr and Pb, may exhibit extreme toxicity even at low levels under certain conditions, thus necessitating regular monitoring of sensitive aquatic environments (Cohen *et al*., 2001). Thus the accumulation of these metals to very high toxic levels could cause severe ecological impact on organisms without any visible signs (Gupta *et al*., 2009). Accumulation of heavy metals in aquatic organisms could lead to a decrease in fecundity of fish populations or it could impact on reproduction. Heavy metals may also alter the physiological activities and biochemical parameters in tissues and blood of aquatic organisms (Vinodhini and Narayanan, 2008). Since the control of reproduction in fishes is complex and affected by a wide range of environmental factors as well as hormones, even low levels of pollution could affect reproduction. Hence, at low levels, even though organisms might not show any ill effects, it can lead to long term decline in fish supply.
Exposure to these heavy metals could ultimately lead to health risks associated with the consumption of crab by humans. Some of these health risks such as renal failure and liver damage can be caused by exposure to lead (Pb). Prolonged exposure to Pb can lead to mental retardation, coma and eventual death. Studies have shown that cadmium (Cd) can cause chronic toxicity such as impaired kidney functioning, hypertension and hepatic dysfunction whereas copper and zinc may cause kidney problems such as nephritis and anuria (Rahman *et al*., 2012). Industrialized areas are at higher risk of contamination with a wide variety of industrial chemicals. These can leach into the soil and groundwater where they enter the food chain and accumulate in animals higher up the food chain (Diamanti-Kandarakis *et al*., 2009). Crab and other aquatic organisms can be exposed to heavy metals via two routes. The primary route for metal intake by crabs is via their gills or dissolved contaminants being transported across biological membranes or through ionic exchange across membranes. The second route is through ingestion of food or sediment particles which is then transported across the gut (Gupta *et al*., 2009). Studies done by (Bervoets *et al*., 2001) showed that the gastrointestinal route is the more important route when it comes to heavy metal uptake.

In Côte d'Ivoire, parts of Ebrie lagoon bays are located in an urban area like Abidjan district.

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Heavy metals are introduced in this aquatic environment through domestic and industrial waste discharge into water body. It is rather of great concern that over 80% of the industries discharge their solid waste, liquid and gaseous effluent containing toxic concentration of heavy metal such as cadmium, lead, cadmium, chromium and zinc into the environment without any prior treatment (Scheren et *al*., 2004 ; Adingra et Kouassi, 2011). Several studies showed that the sediments of Ebrie lagoon are polluted by heavy metal (Tastet *et al*., 1984; Marchand et Martin, 1985 ; Coulibaly et *al*., 2008 ; Soro et *al*., 2009 ; Kouassi, 2014; Daniel et *al*, 2016). The aim of this work is therefore to determine the heavy metals (As, Cd, Cr, Pb, Zn) concentration in a marine organism (crab *Callinectes amnicola*) in six bays of Ebrie lagoon so as to compare the level of heavy metals in crab with the consumable standard with a view of determining their suitability for human consumption.

MATERIALS AND METHODS

Study Area: The study was carried out in six bays of Ebrie lagoon in Abidjan area (Figure 1). The coordinates of the sampling stations are indicated in table1.

Sample Collection and preparation

The sampling stations mere selected to reflect progression of pollution and human activities in the area. The samples were collected on two different dates, 10/07/2015 and 20/02/2016. Ten fresh (life) samples of crab used for analysis were randomly collected directly, by hand picking, from their holes at each of the six bays (Cocody, Koumassi, Banco, Marcory, Yopougon, Bietry) of Ebrie lagoon, as shown on figure 1 and table 1. Finally, sixteen (60) matured crabs (*Callinectes amnicola*) were collected. The crabs were kept in plastic sachets and transported to the laboratory. Each crab was properly cleaned by rinsing with distilled water to remove debris, planktons and other external adherent. Data such as length (mm), weight of the sample (g) were measured and then frozen at 10°C prior to analysis.

Acid digestion

The method used here is the dry method by Milhaud and Mehennaoui (1988). Each sample of crab entire is washed and put in a cap of porcelain, after the weight was taken. The samples were kept in hot air oven 150°C during 1h, 300°C during 1h and 450°C 16h.

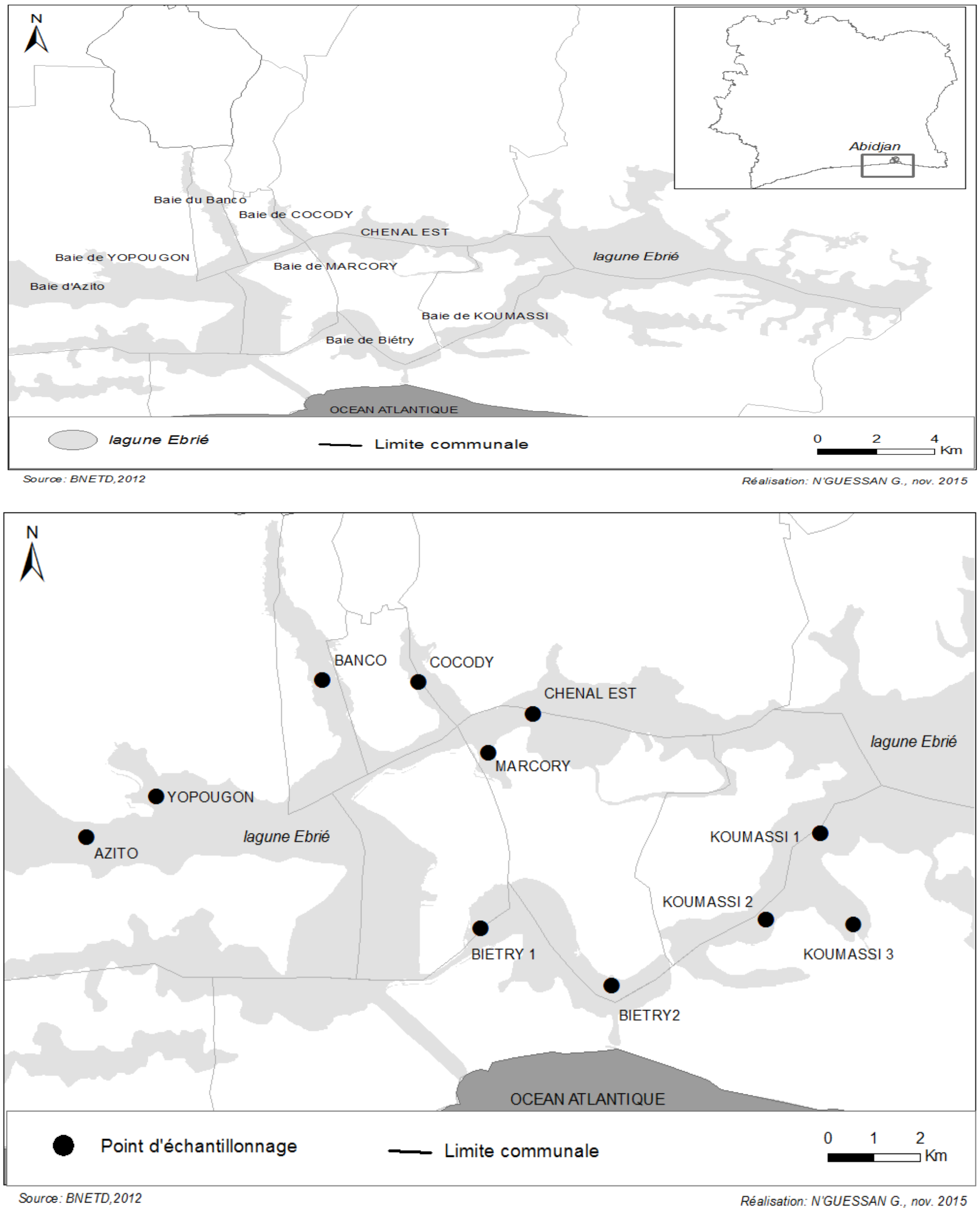

Figure 1. Map showing study site and sampling stations

Table 1. Coordinates of sampling stations

Bay	Sampling Stations	Coordinates (GPS)
Biétry bay	B1 (Bietry 1)	05°16,752N ; 04°00,098W
	B2 (Bietry 2)	05°16,081N ; 03°58,539W
Koumassi bay	K1 (Koumassi 1)	05°17,882N ; 03°56,090W
	K2 (Koumassi 2)	05°16,863N ; 03°55,719W
	K3 (baie de Koumassi 3)	05°16,457N ; 03°55,801W
Yopougon bay	AZ (Azito)	05°17,821N ; 04°04,740W
	BY (Yopougon)	05°18,316N ; 04°03,917W
Banco bay	Ba (Banco)	05°19,691N ; 04°01,969W
Marcory bay	M1 (Marcory)	05°18,837N ; 04°00,003W
Cocody bay	BC (Cocody)	05°19,677N ; 04°00,833W
	CE (Chenal Est)	05°19,298N ; 03°59,483W

Table 2. Characteristics of sample crabs

Samp. code	Bay	Nomb. Indiv.	Length max (cm)	Leng. min (cm)	Leng. mean (cm)	weight max (g)	weight min (g)	weight mean (g)	Part of Water in crabs (%)
CC	Cocody	10	12,6	11,0	13,8	79,3	73,5	75,2	72,3
MA	Marcory	10	16,9	13,0	14,2	83,0	72,0	78,5	73,4
BA	Banco	10	17,0	11,2	15,3	101,1	75,8	89,3	74,8
BI	Biétry	10	15,1	12,3	13,1	98,2	73,5	71,1	74,2
YOP	Yopougon	10	16,6	11,4	14,5	103,0	91,7	102,5	73,6
KM	Koumassi	10	17,0	13,4	15,7	104,6	93,0	102,0	72,9

Table 3. Results of crab analysis in lagoon bays of Abidjan city in July 2015 Heavy metals concentrations in crabs (mg/kg dw)

Code	Sites (Bays)	Number	Zn	As	Cr	Pb	Cd
CC	Cocody	10	181,73	2,27	13,58	4,39	1,25
MA	Marcory	10	125,05	1,37	15,25	3,39	0,75
BA	Banco	10	98,26	3,2	10,8	6,76	0,85
BI	Biétry	10	142,22	4,05	14,21	2,09	0,58
YO	Yopougon	10	209,51	4,66	16,02	3,12	0,97
KM	Koumassi	10	143,27	2,97	7,83	3,04	1,07
	Mean		150,01	3,09	12,95	3,80	0,91
	Standard deviation		39,88	1,19	3,08	1,63	0,24

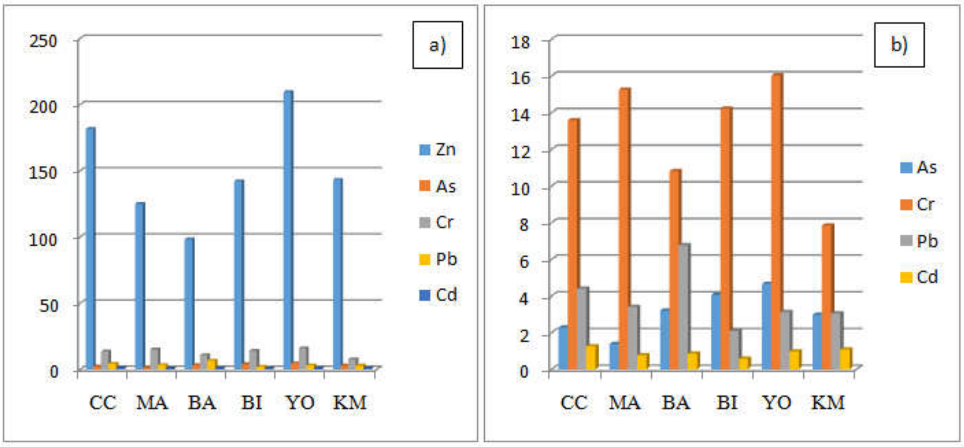

Figure 2. Heavy metals concentrations in crabs (mg/kg dw) in lagoon bays of Abidjan city in July 2015: a) with zinc; b) without zinc

The next day, samples were removed from oven and put out for cooling. Then they were grounded using mortar and pestle and kept separately in label falcon tubes prior to digestion.

An accurate powder sample dry weight 0.5 g was gently digested with 2 mL of nitric acid (HNO_3) in tube of 20mL on a hotplate. The digested sample was allowed to cool and was filtered into a graduating cylinder and the filtrate was made up to 20 mL using distilled water. The digests were kept in plastic bottles and later the heavy metal concentrations were determined using an atomic absorption spectrophotometer (AAS).

RESULTS AND DISCUSSION

Morphology of crabs and water percentage

The crabs captured have different sizes. The matured crabs we considered are those with size between 11 cm and 17 cm, and weight 72 g to 104.6 g (Table 2). The percentage of water is calculated using the weight of each crab, before drying (fresh weight: fw) and after drying (dry weight: dw). Results showed that the crab samples have high percentage of water (72,3 % to 74,8%).

Table 4. Mean concentrations of heavy metals in crabs compared to international guidelines

Metal (x)	As	Cd	Cr	Pb	Zn
Cx(mg/kg dw)	3,09	0,91	12,95	3,80	150,01
*Cx(mg/kg fw)	1,08	0,25	3,56	1,05	41,55
MPL**	0,1mg/kg dw	0,5 mg/kg fw	1,0 mg/kg dw	0,5 mg/kg fw	50 - 1000 mg/kg fw
References	WHO, 1983	C.E, 2011	Nauen, 1983	C.E, 2011	Nauen, 1983

** MPL : Maximum Permissible Limits.
* Concentration translated in mg/kg of fresh weight using formula:

The results of analyses are summarized in Table 3. The crabs collected from different bays presented varying concentrations in the heavy metals As, Cd, Cr, Pb and Zn. The highest concentration of zinc is found in crabs collected in Yopougon bay (209.51mg/kg dw), while the lowest concentration of zinc (98.26 mg/kg dw) came from crabs collected in Banco bay. For all the bays, the mean of concentration of zinc was 150.01 mg/kg of dry weight. Concerning arsenic, its concentrations vary between minimum value 1.37 mg/kg obtained in Marcory bay and a maximum value of 4.66 mg/kg obtained in Yopougon bay. The mean value of arsenate in all the study area was 3.09 mg/kg. We can see that the results of As are highly lower than those obtained with Zn. The mean values of over metals are respectively 12.95 mg/kg for Chromium (Cr), 3.80 mg/kg for lead (Pb) and 0.91 mg/kg for cadmium (Cd). The figure 2-a) shows the highest level of Zn, compared to the over metals (As, Cr, Pb, Cd) in the crabs from all bays studied. So, to have a good view of the figure, we have presented the figure2-c) where Zn is not included. This figure shows that, other than Zn, chromium has the highest level concentration in crab, followed by Pb, As and Cd. Of all the metals analyzed, Cd has the lowest mean concentration of 0.91 mg/kg, while Zn with a mean value of 150.01 mg/kg has the highest concentration in the crab samples. Overall metal bioaccumulation in the crabs entire is in Zn > Cr > Pb > As > Cd order. Cx (mg/kg fw) = Cx(mg/kg dw).(100 - %H)/100, where %H represents the percentage of dampness in the crabs. For the calculations, we have considered the minimum of the value of %H obtained from all the samples of crabs, i.e. 72.3% (Table 2).

DISCUSSION

In this study, the concentrations of heavy metals: As; Cd; Cr; Pb and Zn found in the crabs (*Callinectes amnicola*) showed that these crabs are contaminated. However, this contamination level for Cd and Zn were lower than the world health origination (WHO) recommended maximum allowable standards in food crab, while it was found that the level chromium, lead and arsenic (Cr,Pb, As) were excessively higher than the Maximum Permissible Limits in food recommended by many countries (India, Canada, USA,..) (Nauen, 1983) and international organizations such as WHO, European Commission (CE, 2003) (Table 4). These results were in accordance with those found by Métongo and Sankaré (1990) who showed that Zn level in *C. amnicola* from Ebrie lagoon were lower than WHO recommendations. So, results of this study showed clearly that heavy metals Cd, and Zn levels were not dangerous for human consumption of crabs, contrary to As, Cr and Pb which level pose a serious health risk for man. This situation might be due to the great level of polluted charges constantly thrown in the lagoon by industries and population. In addition, it was demonstrated that sediments of Ebrie lagoon were contaminated by several heavy metals like As, Cd, Pb which have non essential biological effects.

Conclusion

From the analysis point of view, crabs sampled from Ebrie lagoon may be consider unsafe for human consumption, because of the Cr and Pb high concentrations in these organisms, even if the concentrations of Cd, As and Zn were acceptable according to WHO recommendations. Therefore, special attention should be given to the water quality and bioaccumulation of metals (arsenic, cadmium, chromium, lead and zinc) in crab, *Callinectes amnicola* from Ebrie lagoon. Moreover, it is also important to monitor the contamination of crab with heavy metals, because frequent consumption of the contaminated crab presents a very serious health risk. It is also suggested that *Callinectes amnicola* may be useful as a potential indicator of metal pollution, but it should be remembered that there is no certainty that the metal concentration in the environment will be accurately reflected in the tissue of the crab, for there exists a degree of regulation and elimination of metal in the body of *Callinectes amnicola.*

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