INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 12, No. 1, p. 98-110, 2018

RESEARCH PAPER

OPEN ACCESS

Evaluation of crab *Callinectes amnicola* contamination by heavy metals (Pb, Cd, Cu, Zn, Fe, Cr, Ni, As) in the complex Nokoué lake Porto-novo lagoon in South Benin

Goussanou Appolinaire[*1], Youssao Abdoul Karim Alassane[4], Toléba Séibou Soumanou[5], Dagan Sourou Bienvenu[1], Bonou Assouan Gabriel[1], Chikou Antoine[2], Mensah Guy Apollinaire[3], Youssao Abdoul Karim Issaka[1]

[1] *Laboratory of Animal Biotechnology and Meat Technology, Department of Animal Production and Health, Polytechnic School of Abomey-Calavi, University of Abomey-Calavi, Benin*

[2] *Laboratory of Hydrobiology and Aquaculture, Faculty of Agronomic Sciences, University of Abomey-Calavi, Cotonou, Benin*

[3] *Agricultural Research Center of Agonkamey, National Institute of Agricultural Research of Benin, Cotonou, Benin*

[4] *Research Unit in Ecotoxicology and Quality Study, Polytechnic School of Abomey-Calavi, University of Abomey-Calavi, Cotonou, Benin*

[5] *Department of Animal Production, Faculty of Agronomic Sciences, University of Abomey-Calavi, Benin*

Key words: Bioconcentration, Metallic trace elements, Water, Organs

http://dx.doi.org/10.12692/ijb/12.1.98-110

Abstract

The surface water and aquatic species contamination by metallic trace elements has become a major concern. The present study aims to determine the contamination levels of metallic trace elements of crab *Callinectes amnicola* caught in the Ganvié, Zogbo and Hwlacomey stations in the complex Nokoué lake Porto Novo lagoon in South Benin. For this, eight metallic trace elements (Pb, Cd, Cu, Zn, Fe, Cr, Ni, As) were analyzed in water, entire crabs and organs using a flame atomic absorption spectrophotometer. Water from Hwlacomey station has significantly recorded the highest concentrations in chrome and arsenic while those of the Zogbo station recorded the highest concentration of iron. Cd and As concentrations were significantly higher in Ganvié samples whereas Cu, Zn, Cr and Ni concentrations were higher in Zogbo samples. The crabs collected in Hwlacomey have meanwhile recorded the highest contents in Pb and Fe. As for the organs, they were also contaminated by the metallic trace elements and the concentrations also varied significantly ($p < 0.05$) between these organs. Gills, ovaries and muscles have significantly recorded the highest copper and zinc contents while the carapace has recorded the highest lead and chromium contents. The claws and the testicles had the highest concentrations of arsenic. In the complex Nokoué lake Porto-Novo lagoon, *Callinectes amnicola* is contaminated by toxic metals at higher concentrations than the standards reference.

[*] **Corresponding Author:** Goussanou Appolinaire ✉ goussanouappolinaire@ymail.com

Introduction

The growing urbanization and the high population growth in African countries have created enormous environmental problems these last years. Industrial, agricultural and craft activities in countries in full economic growth have caused a rapid increase of various pollutants (heavy metals and organochlorine compounds) in receiving waters such as lagoons, lakes, rivers and seas (Gnandi *et al.*, 2007). Rejected directly into the surface water, emitted into the atmosphere, discharged into the wastewater or spread on soils, most of the pollutants always finally join aquatic environments (Al Kaddissi, 2012).

The presence of pollutants in the various components of the aquatic environment poses serious problems because of their toxicity and their potential accumulation in several aquatic species causing devastating effects on the ecological balance of the aquatic environment and on the consumers' health (Katemo *et al.*, 2010).

The accumulation of toxic metals through the food chain causes in humans serious diseases and other physiological disorders often very severe (Fisk *et al.*, 2001, Oliva *et al.*, 2001, Baldi *et al.*, 2003). Heavy metals for example act on ribonucleic acid (RNA), deoxyribonucleic acid (DNA), enzymes, hormones, free radicals and on the immune system (Nash, 2005). They also cause malfunctions of the circulatory system and of the neurological, hepatic and renal systems (Testud, 2005, Viala and Grimaldi, 2005). In some ecosystems, they are at the base of the disappearance of certain animal and vegetable species, migrations of species and consequently can lead to the dysfunction of the food system (Keumean *et al.*, 2013, Dimon *et al.*, 2014).

The different studies carried out in Cameroon (Ekengele *et al.*, 2014), Congo (Katemo *et al.*, 2010), Côte d'Ivoire (Koné *et al.*, 2007, Issola *et al.*, 2009, Soro *et al.*, 2009; Yao *et al.*, 2009, Yapi Dope *et al.*, 2012), Ghana (Obodai *et al.*, 2011), Guinea (Onivogui *et al.*, 2013), Niger (Tankari Dan Badjo *et al.*, 2014), Nigeria (Obasohan *et al.*, 2006, Obasohan and Eguavoen 2008, Olowu *et al.*, 2010, Oyebissi *et al.*, 2012, Omuvwie and Atobatele, 2013), Chad (Kayalto *et al.*, 2014), Togo (Gnandi *et al.*, 2006, Gnandi *et al.*, 2007, Melila *et al.*, 2012, Kantati *et al.*, 2013, Melila *et al.*, 2013, Kamilou *et al.*, 2014) and in several countries not documented by the literature reveal a contamination of the different environmental compartments (water, sediments and aquatic species) by the metallic trace elements.

In Benin, aquatic ecosystems don't escape to this sad fact. First, studies have been undertaken on water and sediment contamination (Chouti *et al.*, 2010a, Chouti *et al.*, 2010b, Kaki *et al.*, 2011, Hounpkatin *et al.*, 2012, Dimon *et al.*, 2014). After these works, fish, shrimp and oysters have also been evaluated (Youssao *et al.*, 2011, Aina *et al.*, 2012, Guédenon *et al.*, 2012, Megnon *et al.*, 2012, Yehouenou *et al.*, 2013). The different works showed that the contamination of the various Benin aquatic compartments by micro-pollutants is a reality. But if water, sediment and fish are contaminated, what about crustacean populations?

Benin's lakes feature a diversity of crustacean species among which *Callinectes amnicola* occupies a prominent place in the human diet. This species is intensely exploited in the south waters of the country, especially the complex Nokoué lake Porto-Novo lagoon and the Ahémé lake where, it supplies the trade channels (Hountogan, 2011, Tohozin, 2012; Dessouassi, 2014). It is therefore, important to evaluate its sanitary quality in order to preserve the consumers' health. This study aims to evaluate the levels of trace metal contamination in crab *Callinectes amnicola* caught and marketed in the complex Nokoué lake Porto-Novo lagoon in south Benin.

Materiel and methods

Study area

The present study was carried out in the complex Nokoué-lake Porto-Novo lagoon, located in South East Benin, between the parallels 6 ° 25 'and 6 ° 38' North latitude and 2 ° 27 'and 2 ° 30' East longitude.

It is connected to the Atlantic Ocean by the Cotonou channel which has a length of 4.5 km. It covers an area of 180 km² and is the largest continental water course in Benin in terms of area, exploitation and productivity (Gnonhossou, 2006). The hydrological regime of the complex Nokoué lake Porto-Novo lagoon corresponds to a low water period (December to April), a high water period (May to June) and a flood period (September to November).

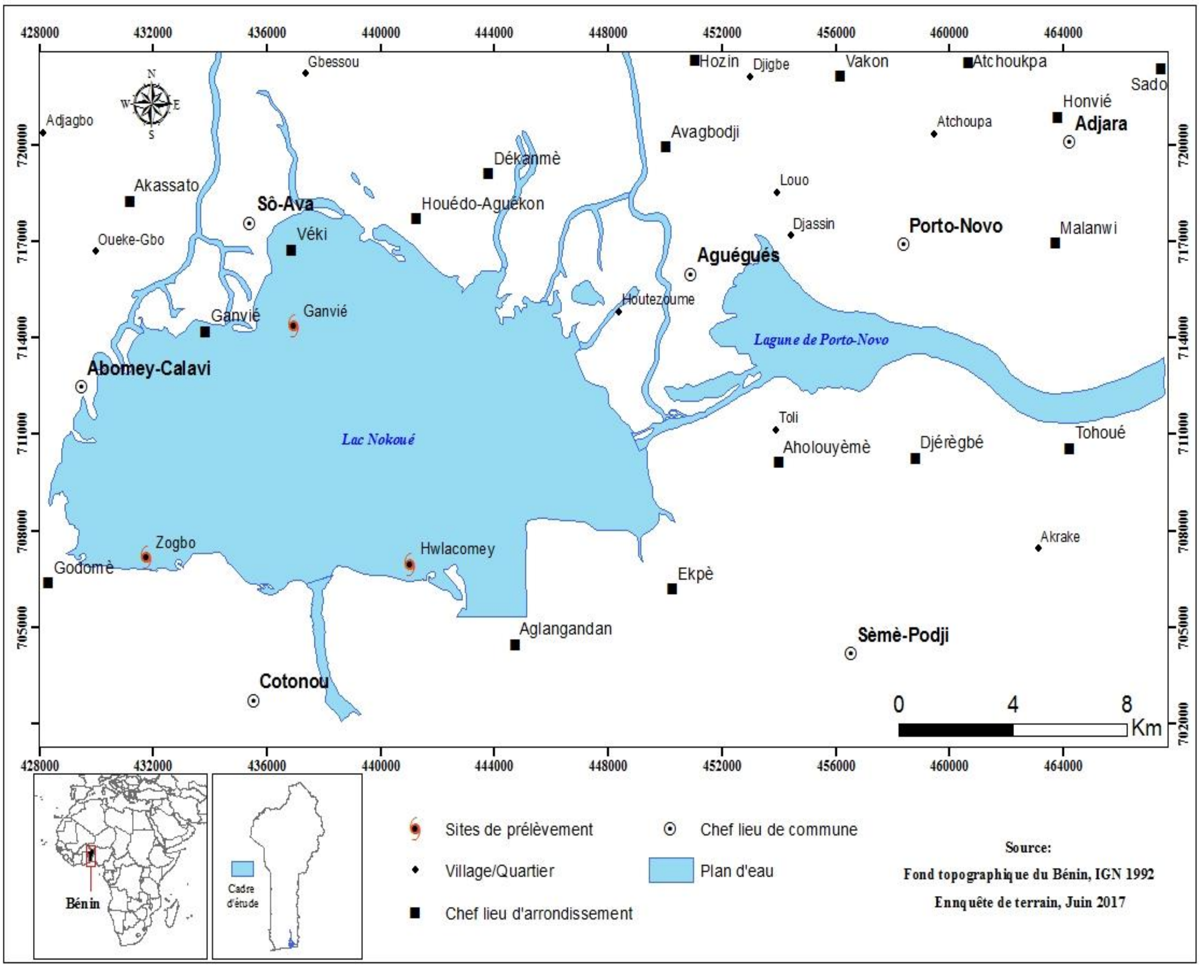

Fig. 1. Location map of sampling stations.

On this ecosystem, Ganvié, Zogbo and Hwlacomey (Fig. 1) were the fishing habitats of crabs *Callinectes amnicola* selected for the study. They were chosen based on the practice of crab fishing activity, the stations accessibility throughout the study period and the collaboration of fishers from these habitats.

Water samples collection

Surface water sampling were performed in the three fishing habitats of crab *Callinectes amnicola*. Water samples were taken into plastic bottles of 1.5 liter numbered and indicating the sampling site. Before sampling, the plastic bottles were rinsed with water from the site to be sampled. Immediately after sampling, each water sample was acidified with nitric acid at 10% and the bottles have been sealed to prevent gas leakage.

Crab Callinectes amnicola samples collection

*Callinectes amnicol*a crabs were collected respectively at the three fishing habitats selected through fishermen. In total, 10 crabs were collected per station. The collected crab samples were put into numbered plastic bags which also have the sampling station indication. Water and crabs samples collected have all been preserved in an icebox containing cold accumulators. These samples were transported to the Laboratory of Animal Biotechnology and Meat Technology of the Polytechnic School of Abomey-Calavi of the University of Abomey-Calavi for the different processing.

Samples processing at the laboratory

Sample processing was performed at the Laboratory of Animal Biotechnology and Meat Technology. The crab samples were first cleaned with tap water to get rid of all debris. After cleaning, they were dissected and the carapace, the claws, gills, muscles, testicles and ovaries as well as entire crabs were processed and dried in an oven (Memmert U50 brand) at 75°C for 72 hours. After drying, the entire crabs and the organs have been finely ground with a porcelain mortar and pestle previously sterilized and sieved.

Determination of metallic trace elements in samples

The determination of metallic trace elements (Pb, Cd, Cu, Zn, Fe, As, Ni and Cr) was performed in the Laboratory of Management, Processing and Valorization of Waste (LMPVW) of the Faculty of Agronomic Sciences of the University of Lomé. For the determination of metallic trace elements, 3 g of each sample was put into teflon tubes to which 6 ml of nitric acid (68%) was added and closed with watch glasses. After solubilization, the tubes were placed in a sand bath gradually heated up to 130 °C of temperature until complete evaporation of the acid. The pellets obtained were dissolved hot with distilled water. After cooling, each solution resulting from the acid attack was measured into a flask of 25 ml. After homogenization, the solution was filtered using a filter paper (0.45 µm). In parallel, two control solutions (6 ml of 68% HNO_3) were prepared under the same conditions. The dosage of metallic trace elements has been done using a flame atomic absorption spectrometer of type Thermo Electron Corporation S Isssue AA Spectrometer.

The determination of metallic trace elements in water samples previously acidified with nitric acid was performed under the same above conditions.

Calculation of bioconcentration factors

Bioconcentration Factors (BCFs) were calculated for each trace element by the formula used by Casas (2005). This is the ratio between the internal concentration of metallic trace elements in the crab organism and the environmental concentration (water).

$$FBC = \frac{Co}{Ce} \text{(Casas, 2005)}$$

Co =trace element concentration in the crab organism

Ce =environmental concentration (water).

Statistical analysis

Statistical analyzes were performed with the SAS software (Statistical Analysis System, 2006). The Proc means procedure was used to calculate the mean of the metallic trace elements. A variance analysis was performed using the Generalized Linear Models (*Proc GLM*) procedure with as variation factors, the sampling station and the organ. The means were compared pairwise by the student t test. The *Proc corr* procedure was used to determine the correlations between metallic trace element levels in water and *Callinectes amnicola* crabs. The *proc princompt* procedure was used to perform a principal component analysis of the different variables.

Results

Water concentration in toxic metals

The toxic metals content of water from the different stations are presented in Table 1.

Table 1. Concentration of heavy metals in the water of the sampling stations of the complex Nokoué lake Porto-Novo lagoon.

Stations	Pb (mg/l)	Cd (mg/l)	Cu (mg/l)	Zn (mg/l)	Fe (mg/l)	Cr (mg/l)	Ni (mg/l)	As (µg/l)
Ganvié	<ddl	<ddl	<ddl	<ddl	0.38b	0.0188a	<ddl	4.28b
Zogbo	<ddl	<ddl	0.0066a	<ddl	3.75a	0.0014b	<ddl	4.08b
Hwlacomey	<ddl	<ddl	0.0132a	<ddl	2.95a	0.0198a	<ddl	5.76a
Standard Error	0.00	0.00	0.009	0.00	1.02	0.01	0.00	0.53
WHO standards	0.01	0.003	0.01	5	0.3	0.05	0.07	0.01

<ddl: inferior to the detection limit. The means of the same column followed by different letters differ significantly at the threshold of 5%. WHO (2006): World Health Organization.

The copper, the iron, the chromium and the arsenic were detected in waters where iron, chromium and arsenic content varied significantly (p <0.05) between sampling stations. For copper contents in water samples, no significant difference (p> 0.05) was observed between the stations. The lead, cadmium, zinc and nickel contents in the analyzed waters were below the detection limit.

Table 2. Concentration of heavy metals in crabs *Callinectes amnicola* of the complex Nokoué lake Porto-Novo lagoon.

Stations	Pb (mg/kg)	Cd (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Fe (mg/kg)	Cr (mg/kg)	Ni (mg/kg)	As (µg/kg)
Ganvié	1.25ab	0.23a	27.02b	111.47b	150.09a	1.83b	0.32b	22.61a
Zogbo	0.82b	0.17ab	31.22a	120.3a	146.3b	2.12a	0.37a	17.44b
Hwlacomey	1.81a	0.11b	25.98b	113.87b	152.15a	2.09a	0.32b	20.27ab
Standard Error	0.29	0.03	1.6	2.64	1.71	0.09	0.02	1.49
WHO standards	0.1	0.01	1	5	0.2	1	0.05	0.1

The means of the same column followed by different letters differ significantly at the threshold of 5%. WHO (2006): World Health Organization.

Chromium (0.0198 mg/l) and arsenic (5.76 µg/l) concentrations were significantly (p <0.05) higher in the water from the Hwlacomey station. On the other hand, iron concentration (3.75 mg/l) was significantly higher in the waters of the Zogbo station.

The concentrations of Pb, Cd, Zn, Cr, Ni and As obtained in the waters of the three sampling stations were all below the WHO recommended thresholds except the copper concentration obtained at the Hwlacomey station and those of iron from the three sampling stations.

Table 3. Correlation between metallic trace elements in crabs *Callinectes amnicola*.

	Pb	Cd	Cu	Zn	Fe	Cr	Ni	As
Pb	1	0.76NS	0.866*	0.901*	0.923**	0.91**	0.877*	0.933**
Cd		1	0.928**	0.921**	0.923**	0.894*	0.922**	0.939**
Cu			1	0.997***	0.991***	0.994***	1***	0.956**
Zn				1	0.998***	0.998***	0.998***	0.97***
Fe					1	0.995***	0.993***	0.982***
Cr						1	0.996***	0.96***
Ni							1	0.958***
As								1

NS: Not Significant (p > 0.05); *: p < 0.05; **: p < 0.01; ***: p < 0.001.

Bioaccumulation of metallic trace elements

The Table 2 shows heavy metal concentrations in crab *Callinectes amnicola* collected in the complex Nokoué lake Porto-Novo lagoon.

These concentrations varied significantly (p <0.05) between the sampling stations. The cadmium (0.23 mg / kg) and arsenic (22.61 µg / kg) concentrations were significantly (p <0.05) higher in crab samples from the Ganvié station. As for the concentrations of copper, zinc, chromium and nickel, they were significantly higher (p <0.05) in crab samples from Zogbo.

On the other hand, samples from Hwlacomey station significantly (p <0.05) recorded the highest concentrations of lead (1.81 mg/kg) and iron (152.15 mg/kg).

The Pb, Cd, Cu, Zn, Fe, Cr and Ni concentrations are all above the standards accepted by the World Health Organization in the fishery resources except those of arsenic.

Correlations between the different contents of metallic trace elements

The Table 3 presents the correlation matrix between metallic trace elements in the crab *Callinectes amnicola*. Apart from the lead and the cadmium, all the metallic trace elements were highly and positively correlated with each other (0.866 <r <0.998, p <0.05). The lowest correlation coefficient was found between the lead and the copper (0.866) and the highest correlation coefficients were obtained between the zinc and the iron, the chromium and the nickel.

Table 4. Concentration of metallic trace elements in the organs of the crab *Callinectes amnicola*.

Organs	Pb (mg/kg)	Cd (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Fe (mg/kg)	Cr (mg/kg)	Ni (mg/kg)	As (µg/kg)
Claws	0,787ab	<ddl	24,107cd	78,14a	60,304c	6,316b	<ddl	18,267a
Carapace	0,883a	<ddl	17,345d	65,369b	216,654a	8,69a	<ddl	10,318b
Muscles	0,535d	<ddl	31,34bc	81,084a	189,673a	5,154c	<ddl	7,254c
Testicles	0,646c	0,123b	37,539c	80,926a	134,127a	2,614d	<ddl	11,361b
Ovaries	0,802ab	0,282a	40,222b	81,302a	129,213b	2,863d	<ddl	9,033b
Gills	0,716bc	<ddl	66,743a	82,68a	241,989a	3,459cd	<ddl	8,497b
Standard Error	0,051	0,046	7,015	2,646	27,294	0,964	0,000	1,605

<ddl: inferior to detection limit. The means of the same column followed by different letters differ significantly at the threshold of 5%.

Distribution of metallic trace elements in organs

The trace metal content in the crabs *Callinectes amnicola* organs are presented in Table 4. The concentrations of metallic trace elements varied significantly (p <0.05) in the different studied organs.The nickel concentrations in crab *Callinectes amnicola* organs were all below the detection limits. The principal component analysis performed revealed that the first two axes concentrate 69.94% of the variations (Fig. 2), which assures and guarantees a precision in the data interpretation.

The projection of metallic trace elements and studied organs in the axes 1 and 2 (Fig. 2) showed that the gills, muscles and ovaries had the highest concentrations of copper and zinc. The highest concentrations of lead and chromium were recorded in the carapace. The highest iron levels were obtained in the carapace and gills.The testicles and the claws have the highest concentrations of arsenic.

Table 4. Concentration of metallic trace elements in the organs of the crab *Callinectes amnicola*.

Organs	Pb (mg/kg)	Cd (mg/kg)	Cu (mg/kg)	Zn (mg/kg)	Fe (mg/kg)	Cr (mg/kg)	Ni (mg/kg)	As (µg/kg)
Claws	0,787ab	<ddl	24,107cd	78,14a	60,304c	6,316b	<ddl	18,267a
Carapace	0,883a	<ddl	17,345d	65,369b	216,654a	8,69a	<ddl	10,318b
Muscles	0,535d	<ddl	31,34bc	81,084a	189,673a	5,154c	<ddl	7,254c
Testicles	0,646c	0,123b	37,539c	80,926a	134,127a	2,614d	<ddl	11,361b
Ovaries	0,802ab	0,282a	40,222b	81,302a	129,213b	2,863d	<ddl	9,033b
Gills	0,716bc	<ddl	66,743a	82,68a	241,989a	3,459cd	<ddl	8,497b
Standard Error	0,051	0,046	7,015	2,646	27,294	0,964	0,000	1,605

<ddl: inferior to detection limit. The means of the same column followed by different letters differ significantly at the threshold of 5%.

Bioconcentration factors in crab Callinectes amnicola

The bioconcentration factors of the metallic trace elements of crab *Callinectes amnicola* and those of their respective organs are presented in Table 5. Bioconcentration factors varied significantly (p <0.05) between different organs. Copper has the highest bioconcentration factor, followed by chromium, iron and arsenic (Table 5). In the organs, the highest bioconcentration factors were obtained in the gills for copper (6674.3) and iron (24198.9). As for chromium and arsenic, their highest bioconcentration factors were obtained in the carapace and the claws, respectively.

Discussion

Metallic trace elements concentration in water

The contamination of surface waters, sediments, soils and aquatic species by trace metals has become a major concern today (Chouti *et al.*, 2010a, Bastami *et al.*, 2012 ; Dimon *et al.*, 2014). According to Katemo *et al.* (2010), water contamination limits its different uses and represents a hazard for aquatic species. In the complex Nokoué lake Porto-Novo lagoon, the waters analyzed were contaminated by the metallic trace elements and the concentrations were generally heterogeneous and varied according to the metal and the sampling site.

Table 5. Bioconcentration factors in metallic trace elements of the entire crab *Callinectes amnicola* and in its organs.

Variable	Pb	Cd	Cu	Zn	Fe	Cr	Ni	As
C. amnicola	-	-	2807	-	63.315	154.615	-	4.269
Claws	-	-	2410.7	-	25.552	485.846	-	3.878
Carapace	-	-	1734.5	-	21665.4	668.461	-	2.19
Muscles	-	-	3134	-	18967.3	396.461	-	1.54
Testicles	-	-	3753.9	-	13412.7	201.076	-	2.412
Ovaries	-	-	4022.2	-	12921.3	220.23	-	1.917
Gills	-	-	6674.3	-	24198.9	266.076	-	1.804

The waters were contaminated by copper, iron, chromium and arsenic. Water pollution by these metals in this ecosystem may be related to the use of paints and pigments, alloys and solders, pesticides, herbicides and preservatives, fuel, dye and fertilizers by local residents. Chromium and arsenic concentrations were significantly higher in the waters from the Hwlacomey station.

This is because this area shelters dyeing activities and is also a high density area where garbage and other solid residues are dumped daily. The waters from the Zogbo station recorded the highest concentrations of iron. The proximity of this station to a landing site of adulterated fuel can explain the high concentration of iron compared to the other stations. The use in this area of paints for the construction of motorized boat is also a cause.

Previous studies carried out on the contamination of the waters and sediments of the complex Nokoué lake Porto-Novo lagoon revealed several sources of pollution whose the most important are the adulterated gasoline traffic, the discharges of untreated domestic waste waters and solid household wastes and the contribution of streaming water that often contain all kinds of particles (Chouti *et al.*, 2010a; Kaki *et al.* 2011, Youssao *et al.*, 2011, Yehouenou *et al.*, 2013). To these factors is added the proximity of the Dantopka market, which has a considerable impact on the waters quality of this ecosystem.

Metallic trace element concentrations in the water were below the WHO recommended limits except those of the copper and iron. Indeed, copper and iron are heavy metals essential for the growth and welfare of organisms including humans. But these metals can have toxic effects when organisms are exposed to higher concentrations than normally needed (Biney *et al.*, 1994, Katemo *et al.*, 2010). The contamination of water with copper and iron represents therefore a major risk for the different uses of water and the concentrations of the other metals should be monitored.

Contrary to the results of this study, Chouti *et al.* (2010a) (Fe: 3.56 mg/l, Cd: 0.10 mg /l, Pb: 2.35 mg/l and Cr: 4.16 mg /l), Kaki *et al.* (2011) (Pb: 0.05 mg /l; Cu: 0.29 mg /l; As: 8.35 mg /l), Youssao *et al.* (2011) (Pb: 1.47 mg/l), Hounkpatin *et al.* (2012) (Pb: 0.56 mg/l, Cd: 0.03 mg/l) and Yehouenou *et al.* (2013)

(Pb: 23.40 mg/l, Cd: 14.81 mg/l, Zn: 52.4 mg/l) reported in this ecosystem higher concentrations of heavy metals. The difference can be explained by the fact that sampling periods and collection stations are not identical and moreover, the complex Nokoué lake Porto-Novo lagoon is a hydrodynamic system. Higher concentrations than in this study have also been reported in the waters of Ahémé lake (Dimon *et al.*, 2014), the waters of the Ouémé River (Guédenon *et al.*, 2012), the waters of the Upper Lufira Basin in the Democratic Republic of Congo (Katemo *et al.*, 2010), the Lagos lagoon waters (Oyebissi *et al.*, 2012), the waters of the Konkouré River in Guinea (Onivogui *et al.*, 2013) and the waters of lake Bini and Dang in Cameroon (Ekengele *et al.*, 2014).

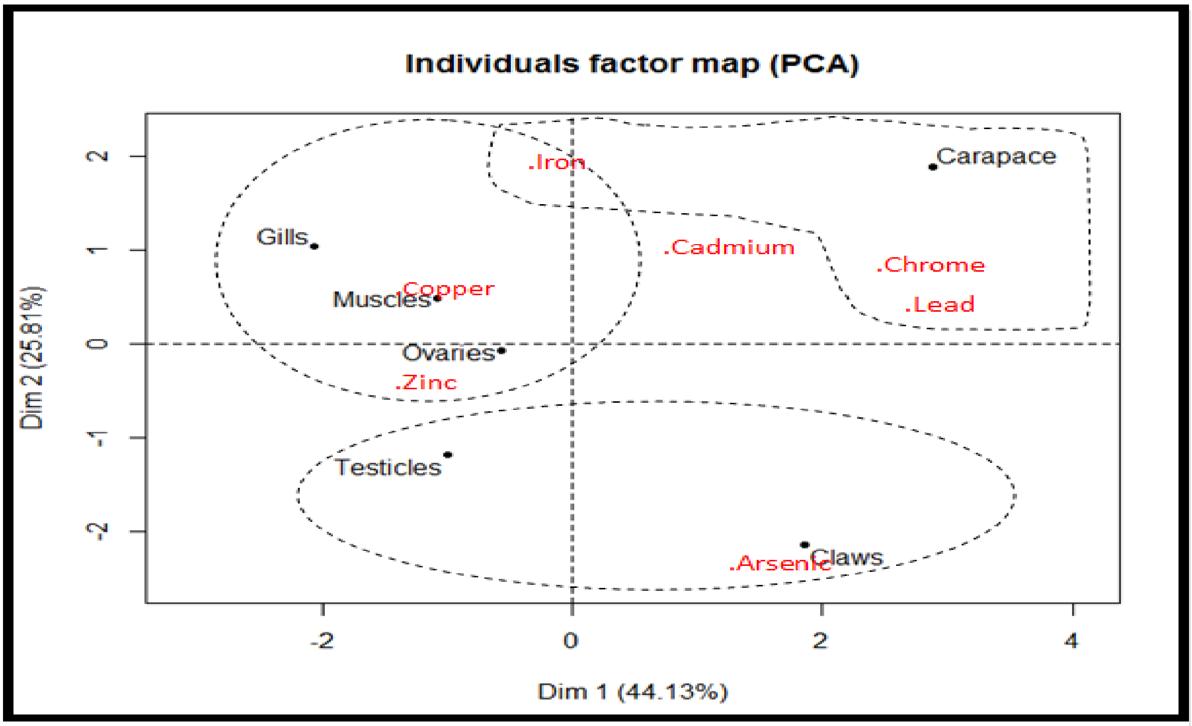

Fig. 2. Principal component analysis conducted on metallic trace elements and studied organs.

Bioaccumulation of metallic trace elements by crab Callinectes amnicola

The contamination of aquatic species by metallic trace elements is of particular interest because of the potential risk to the perennity of these aquatic species and to the health of the populations that consume them (Youssao *et al.*, 2011; Aina *et al.*, 2012; Bastami *et al.*, 2012; Kamilou *et al.*, 2014). A wide range of values for metal trace element concentrations were obtained for the crab *Callinectes amnicola*. In this species, heavy metals concentrations were heterogeneous and varied significantly with site and metal. These concentrations don't reflect the levels of metallic trace element contamination of the water at the sampling stations, which explains the heterogeneous concentrations obtained. This heterogeneity in the distribution of metallic trace elements may be related to the migratory capacity of the species. Indeed, crabs *Callinectes amnicola* are non-sedentary species able to migrate and to frequent all stations. The bioaccumulation of toxic metals by aquatic species may therefore depend not only on the environment concentration in metallic trace elements (Youssao *et al.*, 2011; Kamilou *et al.*, 2014) but also on the migratory capacity of the species.

The high accumulation of toxic metals by these species is related to their feeding patterns (Gnandi *et al.*, 2006, Fatemi and Shahrzad, 2016, Gbogbo *et al.*, 2016). Crabs are omnivorous, predatory and necrophagous species. They filter the mud to eat themselves and this allows them to concentrate considerable quantities of toxic metals present in the environment via the gills or the digestion of the contaminated particles.

Indeed, this ability of crabs to absorb metallic trace elements has been documented and used by some authors to evaluate the pollution status of some rivers. This is the case of the European green crab *Carcinus maenas* which has been used as a pollution bioindicator (Brian, 2005, Stentiford and Feist, 2005, Moreira *et al*., 2006). Except contamination through the trophic chain, it is also important to underline that the bioaccumulation of metallic trace elements by this species is also linked to other factors such as the environment physicochemical conditions, the bioavailability of the metallic trace element, the physiological capacity of assimilation and excretion of the trace element by the concerned species, but even to the ubiquitous character of metallic trace elements in the environment (Miquel, 2001, Casas, 2005). According to their contamination levels in metallic trace elements, the consumption of these species must be strictly regulated. Metal trace element levels in *Callinectes amnicola* crab in our study are significantly higher than those reported by Omuvwie and Atobatele (2013) on the same species in Nigeria. On the other hand, Bastami *et al.* (2012) reported in Iran on the crab *Portunus pelagicus*, higher concentrations than the results of this study.

Distribution of metallic trace elements in crab Callinectes amnicola organs

Metallic trace element concentrations in the organs of crabs *Callinectes amnicola* were heterogeneous and varied among the studied organs. All the metallic trace elements were identified in the organs of the crabs *Callinectes amnicola* except the Nickel whose concentration was below the limit of detection. Among the organs studied in this species, the gills are the most exposed organs to contaminants. The concentrations of metallic trace elements in this organ were very high and this is justified by the fact that gills are the organ that directly intervenes in the different processes of water and mud filtration. The same observation was also reported by Omuvwie and Atobatele (2013) on the contamination of crab *Callinectes amnicola* organs in Nigeria. Lead and zinc contents in the organs were very superior to those reported by Omuvwie and Atobatele (2013) even in crab *Callinectes amnicola* organs in Nigeria. In *Callinectes amnicola*, the iron, zinc, lead, nickel contents in the claws, gills, carapace and muscles were very higher than those reported by Oyebisi *et al.* (2012) in organs of the same species in Nigeria.

The contamination of crabs *Callinectes amnicola* organs by toxic metals especially the reproductive organs that are the testicles and the ovaries is a real hazard for the survival and for the perennity of this species. Indeed, it has been shown that the exposure of aquatic species to metallic trace elements can lead to harmful effects such as the fertility decrease, the species disappearance, the mortality,the lower growth and in some cases can lead to sex inversions in certain species (Chouti *et al*., 2010a, Keumean *et al*., 2013, Dimon *et al*., 2014).

Conclusion

The water and crab *Callinectes amnicola* collected in complex Nokoué lake Porto-Novo lagoon are contaminated by Pb, Cd, Cu, Zn, Fe, Cr, Ni and As. Organs such as claws, carapace, muscles, testicles, ovaries and gills of crabs *Callinectes amnicola* are also contaminated with identified trace metal elements. Levels of concentration in metallic trace elements of crab *Callinectes amnicola* and their respective organs exceed the required standards and therefore, represent a major risk to the health of consumers and to the perennity of species. The use of complex Nokoué lake Porto-Novo lagoon water and the consumption of crab *Callinectes amnicola* must be monitored.

Acknowledgements

The authors thank the “Ministère de l’Enseignement Supérieur et de la Recherche Scientifique du Bénin” for its financial support.

References

Aina MP, Degila H, Chikou A, Adjahatode F, Matejka G. 2012. Risk of intoxication by heavy metals (Pb, Cd, Cu, Hg) connected to consumption of some halieutic species in Lake Nokoué: case of the *Penaeus shrimps* and the Sarotherodon melanotheron. Bristish Journal of Science **5(1),** 104-118.

Al Kaddissi S. 2012. Comparaison de la réponse (en termes d'accumulation, d'impacts cellulaires et génétiques) de l'écrevisse *Procambarus clarkii* après exposition à un polluant métallique (cadmium) et un polluant radiologique (uranium 238 et 233). Thèse de doctorat de l'université Bordeaux1, 333p.

Baldi I, Lebailly P, Mohammed-Brahim B, Letenneur L, Dartigues JF, Brochard P. 2003. Neurodegenerative diseases and exposure to pesticides in the elderly. American Journal of Epidemiology **157(5),** 409-414.

Bastami AA, Khoei JK, Esmailian M. 2012. Bioaccumulation of heavy metals in sediments and crab, *Portunus pelagicus* from Persian Gulf, Iran. Middle-East Journal of Scientific Research **12(6),** 886-892. http://dx.doi.org/10.5829/idosi.mejsr.2012.12.6.661

Biney C, Amuzu AT, Calamari D, Kaba N, Mbome LI, Naeve H, Ochumba O, Osibanjo O, Radegonde V, Saad MAH. 1994. Etude des métaux lourds. Revue de la pollution dans l'environnement aquatique africain, FAO **(25)**, 37-67.

Brian JP. 2005. Inter- population variability in the reproductive morphology of the shore crab (*Carcinus maenas*): evidence of endocrine disruption in a marine crustacean? Marine Pollution Bulletin **50,** 410-416.

Casas S. 2005. Modélisation de la bioaccumulation de métaux traces (Hg, Cd, Pb, Cu et Zn) chez la moule, *Mytilus galloprovincialis* en milieu méditerranéen, thèse de Doctorat, Université du Sud Toulon France, 301 p + annexe.

Chouti W, Mama D, Alapini F. 2010a**.** Etude des variations spatio-temporelles de la pollution des eaux de la lagune de Porto-Novo (sud Bénin). International Journal of Biological and Chemical Sciences **4(4),** 1017-1029.

Chouti W, Mama D, Changotade O, Alapini F, Boukari M. 2010b**.** Etude des éléments traces métalliques contenues dans les sédiments de la lagune de Porto-Novo (Sud Bénin). Journal of Applied Biosciences **34**, 2186-2197.

Dimon F, Dovonon F, Adjahossou N, Chouti W, Mama D, Alassane A, Boukari M. 2014. Caractérisation physico- chimique du lac Ahémé (sud Bénin) et mise en relief de la pollution des sédiments par le plomb, le zinc et l'arsenic. Journal de la Société Ouest- Africaine de Chimie **037**, 36-42.

Ekengele NL, Oumar B, Balla OAD. 2014. Evaluation du niveau de pollution par les métaux lourds des lacs Bini et de Dang, Région de l'Adamaoua, Cameroun. Afrique Science **10 (2**), 184-198.

Fatemi F, Shahrzad K. 2016**.** Investigation of cadmium and arsenic accumulation *Portunus pelagicus* along the Asalouyeh Coast, Iran. Journal of Earth, Environment and Health Sciences **2(1),** 34-38. http://dx.doi.org/10.4103/2423-7752.181805

Fisk AT, Hobson KA, Norstrom RJ. 2001. Influence of chemical and biological factors on trophic transfer of persistent organic pollutants in the Northwater polynya marine food web. Environmental Sciences and Technologies **35**, 732-738.

Gbogbo F, Otoo SD, Huago RQ, Asomaing O. 2016**.** High levels of mercury in wetland resources from three river basins in Ghana: A concern for public health. Environmental Sciences Pollution Research, 9 p. http://dx.doi.org/10.1007/s11356-016-8309-2.

Gnandi K, Tchangbedji G, Killi K, Baba G, Abbe K. 2006. The impact of phosphate mine tailings on the bioaccumulation of heavy metals in marine fish and crustaceans from the coastal zone of Togo. Mine Water and the Environment **25**, 56-62.

Gnandi K, Tomety-Mensah F, Ameyapoh Y, Edorh P. 2007**.** Distribution, biodisponibilité et bioaccumulation des métaux lourds dans le système lagunaire de Lomé. Journal de la Recherche Scientifique de l'Université de Lomé (Togo) série A **9 (1),** 67-81.

Gnonhossou P. 2006. La faune benthique d'une lagune Ouest Africaine (le lac Nokoué au Bénin), diversité, abondance, variation temporelles et spatiales, place dans la chaine trophique. Thèse de doctorat de l'Institut National Polytechnique de Toulouse.

Guedenon P, Edorh AP, Kaki C, Yehouenou APE, Gnandi K, Montcho S, Hounkpatin A, Koumolou L, Boko M. 2012. Arsenic, Cadmium, Copper and Lead accumulation in water, sediments and fish species of Oueme River in Bonou. British Journal of Pharmacology and Toxicology **3(1),** 13-20.

Hounkpatin AS, Edorh AP, Sèzonlin M, Guédénon P, Elégbédé B, Boni G, Dougnon V, Montcho S, Kéké E, Boko M. 2012. Pollution of aquatic ecosystems by heavy metals at Ganvié's lacustrine city (Benin). International Research Journal of Biotechnology **3(6)**, 81-87.

Issola Y, Kouassi AM, Dongui BK, Adingra AA, Biemi J. 2009. Concentration en métaux lourds des sédiments d'une lagune côtière tropicale : lagune de Fresco (Côte d'Ivoire). Journal of Applied Biosciences **18,** 1009-1018.

Kaki C, Guedenon P, Kelome N, Edorh PA, Adechina R. 2011. Evaluation of heavy metals pollution of Nokoué Lake. African Journal of Environmental Science and Technology **5(3),** 255-261.

Kamilou OS, Hodabalo DS, Kissao G, Komlan MA., Esso JB. 2014. Evaluation et risques sanitaires de la bioaccumulation de métaux lourds chez des espèces halieutiques du système lagunaire Togolais. Vertigo **14(2),** 1-18.

Kantati YT, Kodjo MK., Gnandi K, Ketoh GK, Gbeassor M. 2013**.** Effects of pollution on oxidative stress in aquatic species : case of the fish *Sarotherodon melanotheron* in Bè Lagoon (Lomé). International Journal of Biological and Chemical and Chemical Sciences **7(2)**, 717-725.

Katemo Manda B, Colinet G, André L, Chocha Manda A, Marquet JP, Micha J.C. 2010. Evaluation de la contamination de la chaîne trophique par les éléments traces (Cu, Co, Zn, Pb, Cd, U, V et As) dans le bassin de la Lufira Supérieure (Katanga/ RD Congo). Tropicultura **28(4)**, 246- 252.

Kayalto B, Mbofung CMF, Tchatchueng JB, Ahmed A. 2014**.** Contribution à l'évaluation de la contamination par les métaux lourds de trois espèces de poissons, des sédiments et des eaux du lac Tchad. International Journal of Biological and Chemical Sciences **8 (2)**, 468-480.

Keumean KN, Bamba SB, Soro G, Soro N, Metongo BS, Biemi J. 2013. Concentration en métaux lourds des sédiments de l'estuaire du fleuve Comoé à Grand-Bassam (Sud-Est de la Côte d'Ivoire). Journal of Applied Biosciences **61**, 4530-4539.

Koné M, Dramane D, Karim Sory T, Ardjouma D, Houenou PV. 2007**.** Niveaux de contamination des ETM (Cu, Zn, Fe, Cd et Pb) dans les tissus mous du gastéropode *Tympanotonus fuscatus* radula collecté dans la lagune Ebrié (Côte d'Ivoire). European Journal of Scientific Research **18(4)**, 628-638.

Megnon GT, Soumanou MM, Tossou S, Mensah GA. 2012**.** Evaluation de la qualité sanitaire des crevettes (*Penaeus* sp) du lac Nokoué au Sud-Bénin : Aspect chimique et microbiologique. Bulletin de la Recherche Agronomique du Bénin, 24-30.

Mélila M, Poutouli W, Amouzou SK, Gado T, Tchao M, Doh A. 2012. Evaluation de l'impact du rejet des déchets phosphates dans la mer sur la biodiversité marine dans trois localités côtières au Togo à partir biomarqueurs du stress oxydati chez Sphyraena barracuda (Heckel, 1843). International Journal of Biological and Chemical and Chemical Sciences **6(2)**, 8820-831.

Mélila M, Poutouli W, Houndji H, Tchaou M, Pakoussi T, Awaga KL, Bilabina I, Tozoou P, Badanaro F, Abalokoka EY, Gnandi K, Agbonon A, Sadikou A, Gado T, Sanni A, Kou'santa A, Guéant JL. 2013**.** Oxidative stress in human due to metallic traces elements bioconcentration in three coastal villages near phosphate treatment factory in Togo. Africa Journal of Food Science and Technology **4(6)**, 141- 147.

Miquel MG. 2001. Les effets des métaux lourds sur l'environnement et la santé, Rapport 261, Office Parlementaire d'Evaluation des Choix Scientifiques et Technologiques, 365 p.

Moreira SM, Guilhermino L, Ribeiro R. 2006. An in situ postexposure feeding assay with *Carcinus maenas* for estuarine sediments-overlying water toxicity evaluations. Environmental Pollution **139**, 318-329.

Obasohan EE, Eguavoen OI. 2008. Seasonal variations of bioaccumulation of heavy metals in a freshwater fish (*Erpetoichthys calabaricus*) from Ogba Rivers, Benin City, Nigeria. African Journal of General Agriculture **4(3)**, 153- 163.

Obasohan EE, Oronsaye JAO, Obano EE. 2006. Heavy metal concentrations in *Malapterurus electricus* and *Chrysichthys nigrodigitatus* from Ogba River in Benin City, Nigeria. Africain Journal of Biotechnology **5(10),** 974-982.

Obodai EA, Boamponsem LK, Adokoh CK, Essumang DK, Villawoe BO, Aheto DW,Debrah JS. 2011. Concentrations of heavy metals in two Ghanaian Lagoons. Archives of Applied Sciences Research **3 (3),** 177-187.

Oliva A, Spira A, Multigner L. 2001. Contribution of environmental factors to the risk of male infertility. Human Reproduction **16(8)**, 1768-1776.

Olowu RA, Ayejuyo OO, Adewuyi GO, Adejoro IA, Denloye AAB, Babatunde AO, Ogundajo AL. 2010. Determination of heavy metals in fish tissues, water and sediment from Epe and Badagry Lagoons, Lagos, Nigeria. E-Journal of Chemistry **7 (1)**, 215-221.

Omuvwie U, Atobatele O. 2013. Growth pattern condition factor, trace metal studies and ectoparasitic load of the blue crab, *Callinectes amnicola* from Lagos Lagoon, Badore, Ajah, Lagos, Nigeria. Cameroon Journal of Experimental Biology **9(1)**, 34-43.

Onivogui G, Baldé S, Bangoura K, Barry MK. 2013. Evaluation des risques de pollution en métaux lourds (Hg, Cd, Pb, Co, Ni, Zn) des eaux et des sédiments de l'estuaire du fleuve Konkouré (Rep. de Guinée). Afrique Science **09(3)**, 36-44.

Oyebisi R, Lawal-Are A, Alo B. 2012. Comparative study of persistent toxic metals levels in land crab (*Cardisoma armatum*) and lagoon crab (*Callinectes amnicola*) in Lagos Lagoon. Scholarly Journals of Biotechnology **1(4)**, 72-79.

Soro G, Metongo BS, Soro N, Ahoussi EK, Kouamé FK, Zade SGP, Soro T. 2009. Métaux lourds (Cu, Cr, Mn et Zn) dans les sédiments de surface d'une lagune tropicale africaine: cas de la lagune Ebrié (Côte d'Ivoire). International Journal of Biological and Chemical Sciences **3(6)**, 1408-1427.

Stentiford GD, Feist SW. 2005. A histopathological survey of shore crab (*Carcinus maenas*) and brown shrimp (*Crangon crangon*) from six estuaries in the United Kingdom. Journal of Invertebrate Pathology **88,** 136-146.

TankariDan-Badjo A, Tidjani DA, Idder T, Guero Y, Dan Lamso N, Matsallabi A, Ambouta JMK, Feidt C, Sterckeman T, Echevarria G. 2014. Diagnostic de la contamination des eaux par les éléments traces métalliques dans la zone aurifère de Komabangou-Tillabéri, Niger. International Journal of Biological and Chemical Sciences **8(6)**, 2849-2857.

Testud F. 2005. Pathologie toxique professionnelle et environnementale, 3è éditions, Eska, Paris, 672 p.

Tohozin YA. 2012. Pêcheries sédentaires, production et commercialisation des tourlourous des lagunes (*Cardisoma armatum*), des crabes bicornes (*Callinectes amnicola*) et des étrilles lisses (*Portunus validus*) dans l'ouest du lac Nokoué en République du Bénin. Journal de la Recherche Scientifique de l'Université de Lomé **14(1)**, 12 -21.

Viala A, Grimaldi F. 2005. Ecotoxicologie. In: Viala A et Botta A, Eléments de toxicologie, 2è éditions, technologie et document Lavoisier, Paris, 245-251.

Yao KM, Soro MB, Trokourey A, Bokra Y. 2009**.** Assessment of sediments contamination by heavy metals in a tropical Lagoon Urban area (Ebrié Lagoon, Côte d'Ivoire). European Journal of Scientific Research **34(2)**, 280-289.

Yapi Dope AC, Kouame V, Tidou AS, Sawadogo B, Wethe J. 2012**.** Cadmium accumulation in tissues of *Sarotherodon melanotheron* (Rüppel, 1852) from the Aby Lagoon System in Côte d'Ivoire. International Journal of Environmental Research and Public Health **9,** 821-830.

Yehouenou EAP., Adamou R, Azehoun PJ, Edorh PA, Ahoyo T. 2013**.** Monitoring of heavy metals in the complex "Nokoué lake-Cotonou and Porto-Novo lagoon" ecosystem during three years in the Republic of Benin. Research Journal of Chemical Sciences **3(5),** 12-18.

Youssao A, Soclo HH, Bonou C, Vianou K, Gbaguidi M, Dovonon L. 2011**.** Evaluation de la contamination de la faune ichthyenne dans le complexe lagunaire Nokoué-chenal de Cotonou par le plomb: cas des espèces *Sarotherondon melanotheron*, *Tilapia guineensis* et *Hemichromis fasciatus* (Bénin). International Journal of Biological and Chemical Sciences **5(2),** 595-602.