Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 27(4): 695- 705 (2023)
www.ejabf.journals.ekb.eg

Heavy metal accumulation in blue crabs (*Callinectes Sapidus*) in Gharb Region, Morocco

Ikram El Qoraychy [1]*, Haytam Rharrhour [1], Othmane Hammani [2], Fatima Wariaghli [1], Feirouz Touhami [3], Hassan Jaziri [1]

[1] Laboratory of Biodiversity Ecology and Genome Faculty of Science Mohammed V University in Rabat, Morocco.
[2] Chemical Analysis platform, UATRS division, CNRST, Rabat, Morocco;
[3] Department of Life Sciences, Polydisciplinary Faculty of Larache, Morocco.
***Corresponding author: i.elqoraychy@um5r.ac.ma**

ARTICLE INFO

Article History:
Received: March 1, 2023
Accepted: July 27, 2023
Online: Aug. 11, 2023

Keywords:
Heavy metals,
Blue crabs,
Callinectes sapidus,
Nador canal,
Merja zerga,
Morocco.

ABSTRACT

The concentrations of metals (Cd, Cr, Cu, Fe, Mn, Ni, Zn, Pb, Al) were evaluated in the blue crabs (*Callinectes sapidus*) tissues collected in January, April, June and September 2022 at two stations in Gharb region of Morocco (lagoon Merja Zerga, Nador canal) using ICP-MS. The metal concentrations in crabs from two stations was not differed significantly. The gill was the major organ accumulating metals, followed by hepathopancreas and muscle tissues. Except for Cadmium, the highest concentrations of metals were measured in the gill. The gill had higher concentrations of all heavy metals except for Fe (Cr 7.37 ± 0.05; Zn 149.9 ±0.05; Ni 2.88 ± 0.025; Cd 1.28 ± 0.1; Mn 136.72 ± 0.075; Fe 530.25 ± 0.075; Cu 138.17± 0.125; Al 179.25±0.1; Pb 27.1±0.025) in Merja zerga and (Cr 8.61± 0.05; Zn 125. 62±0.05; Ni 3.77± 0.025; Cd 1.24± 0.1; Mn 204.42 ± 0.075; Fe 380.75 ± 0.075; Cu 166.22 ± 0.125; Al 230 ±0.1; Pb 34.35±0.025) in Nador canal compared to muscle (Cr 5.22 ± 0.05; Zn 135.7± 0.05; Ni 2.44 ± 0.025; Cd ±1.34 0.1; Mn 245.95 ± 0.075; Fe 656 ± 0.075; Cu 156.62 ± 0.125; Al 229.25 ±0.1; Pb 11.92 ±0.025) in Merja zerga and (Cr 2.92 ± 0.05; Zn 168.82 ±0.05; Ni 2.05 ± 0.025; Cd 1.22 ± 0.1; Mn 141.25 ± 0.075; Fe 430.5± 0.075; Cu 155.4 ± 0.125; Al 254±0.1; Pb 20.35 ±0.025) in Nador canal. Among the metals analyzed, Cu, Zn, Fe, Al and Mn were the most abundant in the different tissues while Cd was the least abundant in *C. sapidus*. Seasonality in the levels of the nine metals was determined. the highest concentrations of all metals were observed in Autumn.

INTRODUCTION

Heavy metals are considered as serious pollutants of the aquatic environment because of their toxicity, high persistence, being non-biodegradable, and tendency to bioaccumulate in organisms **(Çoğun *et al.*, (2017)**, they are very toxic to both humans and the wildlife. The sources of this pollution comes from geochemical origins, or anthropogenic activities: mining, agriculture, industrial processes, urban development, consumption and exploitation of fossil resources, and others; that alter the different biological systems balance, generating environmental pollution **(Ansari *et al.*, 2004)**. Heavy metals, such as cadmium, lead, chromium, mercury and metalliod of arsenic have been implicated with high toxicity and in carcinogenicity **(Oluowo & Olomukoro, (2017)**. Crustaceans are good indicators of heavy metal contamination of marine environments **(Chou *et al.*, (2002)**; **Türkmen *et al.*, (2006)** because heavy metal biomonitor should have the ability to accumulate contaminants in its tissues in a way that the accumulation is consistent with changes in the amount of pollutants in the environment (**Saadatia *et al.*, (2019).** C. sapidus is the most important commercial crustacean of the benthic macroinvertebrates, because they are used for human consumption, they are important source of essential elements such as vitamin D, selenium and some metals (Fe, Zn, Mn, Ca, Na, K and P) for growth and well-being and also of non-essential elements such as Hg and Cd harmful for humans (**Naczk *et al.*, (2004)**. Metals can be easily accumulated into the aquatic organisms from the water and sediment by the means of food web (**Alibabić *et al.*, (2007)**; (**Burger *et al.*, (2007)**. Blue crabs, *Callinectes sapidus Rathbun*, are important members of the estuarine food chain due to high abundance and their multiple role as scavengers, predators and prey (**Jop *et al.*, (1997)**, they have the capability of accumulating heavy metals (**Kumar *et al.*, (2000)** and they are an excellent bioindicator ometal contamination. Hepathopancreas is the key site of heavy metal accumulation in Crustacean (**Reinecke *et al.*, (2003)** and the gills are one of the entry points for harmful substances since they are a large adsorptive organ system (**Reichmuth *et al.*, (2010).**

C. sapidus are economically important and consumed by people, to our knowledge, no study has been published about heavy metal bioaccumulation in Morocco and especially in Merja lagoon and Canal Nador. The purpose of this study is to determine heavy metals in hepathopancreas, gills and muscle tissues of callinectes sapidus as biological indicator of heavy metals for insight into health risks associated with humans consuming the crabs.

MATERIALS AND METHODS

2.1 Study site.

The lagoon of Merja Zerga is the most important wetland in Morocco, is between the towns of kenitra, in the north 70 km and in the south of larache 35 km in the north-western corner of the gharb region Merja Zerga is located at the north-western end of the Gharb plain, in the immediate south of the seaside village of Moulay Bouselham, It is part of the territory of the province of Kenitra (circle of Lalla Mimouna), it depends on the communes of Moulay Bouselham and Sidi Mohamed Lahmer (**Benhoussa *et al.*, (2003)**. Fresh water arrives in this ecosystem through the Nador Canal to the south and the Wadi Drader to the east. The drader river and the Nador canal supplies it with fresh water **(El Qoraychy *et al.*, (2015)**. The Nador Canal, built in 1953, drains the M'da watershed over 700 km as well as the right bank of Sebou River (**Fraikech *et al.*, (2005) Fig.1**.

The study sites were located in Rharb region in Morocco. We collected samples of *C. sapidus* at lagoon Merja Zerga and the Nador Canal.

2.2 Catching and measuring crabs.

Individuals of C. sapidus were caught from two locations in Merja Zerga and Nador Canal in Rharb region in Morocco (Fig. 1). The specimens were captured seasonally (4 times per year) during April, June, September and January 2022/2023 by a professional fisherman. The samples were placed in plastic bags, transported on ice, and stored at – 20°C until further analysis in the laboratory. Each crabs were properly cleaned with water to remove debris, planktons and other external adherent. Individual were collected from each station during each season (total n=135) 66 Females and 69 males (n=77 crabs in Merja zerga and n=71 in Canal Nador) to determine metal concentrations in tissues. For each captured specimen sexe, length and weight were determined. The mean length and weight of the crabs were 17±1.40 cm and 320.9±3,8 g, respectively. Before analysis, Hepatopancreas, gill and muscle tissues was dissected separately. Tissues samples were dried at 105°C for 2 days in the oven.1g for Samples were transferred into digestion flasks and 2 mL of Nitric acid was added and then digestion flasks were put on a hot plate set to 100°C for 2 h The remaining digested solution was transferred to 30 mL flasks and diluted to volume 25 with distilled water, and metal concentrations in the samples were measured on ICP-MS method (ultima expert).

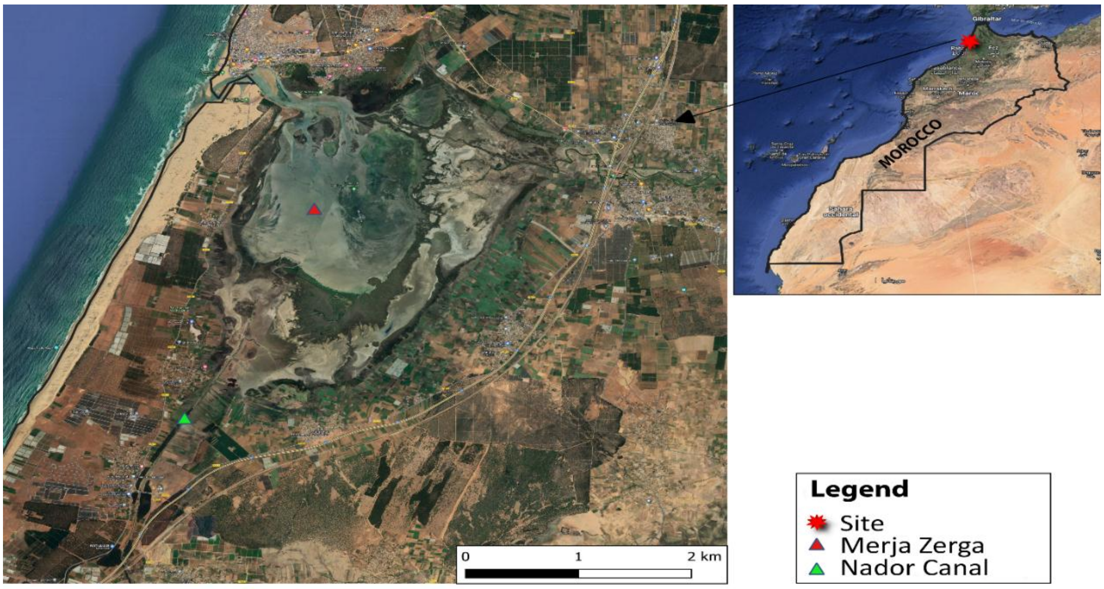

Figure 1: Map showing sampling locations of Merja Zerga (MZ) and Nador canal (NC).

2.3 Statistical analysis.

The study data used were subjected to analysis of variance (ANOVA), regression, and correlation coefficients to show significant differences in the seasonally metal concentrations in the organisms.

RESULTS AND DISCUSSION

Metal concentrations in the hepatopancreas, gill and muscle tissues of C. sapidus are presented in **Tables 1, 2, 3, 4, 5, 6, 7, 8** and **9**. The mean concentrations of cadmium, lead chromium, copper, iron, manganese, nickel, zinc and aluminum in tissues of blue crab, Callinectes sapidus, from Merja Zerga and Canal Nador in Gharb region of Morocco were given in **Tables** below.

Table 1: Mean concentrations of chromium (µg/g dry weight ± SEM) in three tissues, collected in four seasons at two sites.

Sites	Seasons	Gills	Hepatopancreas	Muscle
Canal Nador	Winter	0.36±0.05 ax	0.57±0.05 ay	0.18±0.05 az
	Spring	0.13±0.05 ax	0.48±0.05 ay	0.15±0.05 az
	Summer	1.70±0.05 ax	0.09±0.05 ay	2.92±0.05 bz
	Automn	8.61±0.05 ax	0.51±0.05 ay	0.13±0.05 bz
Merja Zerga	Winter	0.07±0.05 ax	2.22±0.05 ay	0.24±0.05 az
	Spring	4.71±0.05 ax	0.20±0.05 ay	5.22±0.05 az
	Summer	1.30±0.05 ax	0.7±0.05 ay	3.34±0.05 bz
	Automn	7.37±0.05 ax	0.25±0.05 ay	0.15±0.05 bz

Different labels (a, b) within a row indicate significant differences among Tissues at each season; different labels (x, y, z) within a column indicate significant differences among tissues at each site (p<0.05).

Table 2 : Mean concentrations of zinc (µg/g dry weight ± SEM) in three tissues, collected in four seasons at two sites.

Sites	Seasons	Gills	Hepatopancreas	Muscle
Canal Nador	Winter	125.62±0.05 ax	68.82±0.05 ay	168.82±0.05 az
	Spring	122.17±0.05 ax	100.32±0.05 ay	140.05±0.05 az
	Summer	77.65±0.05 ax	136.07±0.05 ay	79.87±0.05 az
	Automn	72.7±0.05 bx	112.9±0.05 ay	123.4±0.05 az
Merja Zerga	Winter	149.9±0.05 ax	81.3±0.05 ay	105.3±0.05 az
	Spring	69.7±0.05 ax	137.77±0.05 ay	78.5±0.05 az
	Summer	129.15±0.05 ax	111.6±0.05 ay	79.8±0.05 az
	Automn	74.75±0.05 bx	136.57±0.05 ay	135.7±0.05 az

Different labels (a, b) within a row indicate significant differences among Tissues at each season; different labels (x, y, z) within a column indicate significant differences among tissues at each site (p<0.05)

Table 3: Mean concentrations of lead (µg/g dry weight ± SEM) in three tissues, collected in four seasons at two sites.

Sites	Seasons	Gills	Hepatopancreas	Muscle
Canal Nador	Winter	0.67±0.025 ax	0.35±0.025 ay	0±0.025 az
	Spring	0.72±0.025 ax	0.13±0.025 ay	0.50±0.025 az
	Summer	7.94±0.025 ax	0.60±0.025 ay	11.92±0.025 az
	Automn	34.35±0.025 bx	0.64±0.025 ay	0.09±0.025 az
Merja Zerga	Winter	0.36±0.025 ax	1.13±0.025 ay	0±0.025 az
	Spring	17.50±0.025 ax	0.73±0.025 ay	20.33±0.025 az
	Summer	0.62±0.025 ax	0.56±0.025ay	0±0.025 az
	Automn	27.1±0.025 bx	0.63±0.025 ay	0.64±0.025 az

Different labels (a, b) within a row indicate significant differences among Tissues at each season; different labels (x, y, z) within a column indicate significant differences among tissues at each site (p<0.05).

Table 4: Mean concentrations of nickel (µg/g dry weight ± SEM) in three tissues, collected in four seasons at two sites.

Sites	Seasons	Gills	Hepatopancreas	Muscle
Canal Nador	Winter	0.39±0.025 ax	2.35±0.025 ay	0.79±0.025 az
	Spring	0.3±0.025 ax	1.4±0.025 ay	0.6±0.025 az
	Summer	1.31±0.025 ax	0.61±0.025 ay	2.05±0.025 bz
	Automn	3.77±0.025 bx	1.47±0.025 ay	0.62±0.025 az
Merja Zerga	Winter	0.14±0.025 ax	1.36±0.025 ay	1.25±0.025 az
	Spring	1.90±0.025 ax	0.35±0.025 ay	2.44±0.025 az
	Summer	0.90±0.025 ax	0.60±0.025ay	1.66±0.025 bz
	Automn	2.88±0.025 bx	0.72±0.025 ay	0.33±0.025 az

Different labels (a, b) within a row indicate significant differences among Tissues at each season; different labels (x, y, z) within a column indicate significant differences among tissues at each site (p<0.05).

Table 5: Mean concentrations of cadmium (µg/g dry weight ± SEM) in three tissues, collected in four seasons at two sites.

Sites	Seasons	Gills	Hepatopancreas	Muscle
Canal Nador	Winter	1.07±0.1 ax	4.24±0.1 ay	0.86±0.1 az
	Spring	0.79±0.1 ax	0.75±0.1 ay	0.66±0.1 az
	Summer	1.07±0.1 bx	1.39±0.1 by	1.22±0.1 az
	Automn	1.24±0.1 bx	0.6±0.1 ay	0.57±0.1 az
Merja Zerga	Winter	0.95±0.1 ax	0.77±0.1 ay	0.73±0.1 az
	Spring	1.17±0.1 ax	0.56±0.1 ay	1.34±0.1 az
	Summer	0.64±0.1 bx	1.13±0.1 by	0.89±0.1 az
	Automn	1.28±0.1 bx	0.68±0.1 ay	0.10±0.1 az

Different labels (a, b) within a row indicate significant differences among Tissues at each season; different labels (x, y, z) within a column indicate significant differences among tissues at each site (p<0.05).

Table 6: Mean concentrations of manganese (µg/g dry weight ± SEM) in three tissues, collected in four seasons at two sites

Sites	Seasons	Gills	Hepatopancreas	Muscle
Canal Nador	Winter	3.58±0.075 ax	21.51±0.075 ay	25.12±0.075 az
	Spring	4.66±0.075 ax	33.9±0.075 ay	23.40±0.075 az
	Summer	90.82±0.075 ax	6.21±0.075 ay	141.25±0.075 az
	Automn	204.42±0.075 bx	22.78±0.075 ay	4.21±0.075 az
Merja Zerga	Winter	3.07±0.075 ax	58.22±0.075 ay	20.39±0.075 az
	Spring	112.22±0.075 ax	12.42±0.075 ay	245.95±0.075 az
	Summer	24.51±0.075 ax	6.73±0.075 ay	81.77±0.075 az
	Automn	136.72±0.075 bx	14.82±0.075 ay	3.12±0.075 az

Different labels (a, b) within a row indicate significant differences among Tissues at each season; different labels (x, y, z) within a column indicate significant differences among tissues at each site (p<0.05).

Table 7: Mean concentrations of iron (µg/g) dry weight ± SEM) in three tissues, collected in four seasons at two sites.

Sites	Seasons	Gills	Hepatopancreas	Muscle
Canal Nador	Winter	31.9±0.075 ax	155.82±0.075 ay	200.87±0.075 az
	Spring	66.32±0.075 ax	238.45±0.075 ay	95.85±0.075 az
	Summer	329±0.075 ax	39.3±0.075 ay	430.5±0.075 az
	Automn	380.75±0.075 ax	413.55±0.075 ay	57.85±0.075 az
Merja Zerga	Winter	47.2±0.075 ax	354.75±0.075 ay	219.75±0.075 az
	Spring	478.75±0.075 ax	203.9±0.075 ay	656±0.075 az
	Summer	120.75±0.075 ax	42.07±0.075 ay	579±0.075 az
	Automn	530.25±0.075 ax	222.37±0.075 ay	38.65±0.075 az

Different labels (a, b) within a row indicate significant differences among Tissues at each season; different labels (x, y, z) within a column indicate significant differences among tissues at each site (p<0.05).

Table 8: Mean concentrations of copper (µg/g dry weight ± SEM) in three tissues, collected in four seasons at two sites

Sites	Seasons	Gills	Hepatopancreas	Muscle
Canal Nador	Winter	45.97±0.125 ax	1.71±0.125 ay	22.62±0.125 az
	Spring	54.6±0.125 ax	141.4±0.125 ay	56.92±0.125 az
	Summer	166.22±0.125 ax	61.67±0.125 ay	155.4±0.125 az
	Automn	118.92±0.125 bx	57.1±0.125 ay	48.37±0.125 az
Merja Zerga	Winter	46.5±0.125 ax	133.85±0.125 ay	77.72±0.125 az
	Spring	138.17±0.125 ax	45.62±0.125 ay	121.1±0.125 az
	Summer	49.77±0.125 ax	59.65±0.125 ay	156.62±0.125 az
	Automn	123.47±0.125 bx	75.32±0.125 ay	44.55±0.125 az

Different labels (a, b) within a row indicate significant differences among Tissues at each season; different labels (x, y, z) within a column indicate significant differences among tissues at each site (p<0.05).

Table 9: Mean concentrations of Aluminium (µg/g dry weight ± SEM) in three tissues, collected in four seasons at two sites.

Sites	Seasons	Gills	Hepatopancreas	Muscle
Canal Nador	Winter	9.30±0.1 ax	56.2±0.1 ay	48.85±0.1 az
	Spring	21.92±0.1 ax	41.67±0.1 ay	27.52±0.1 az
	Summer	230±0.1 ax	10.94±0.1 ay	254±0.1 az
	Automn	154.5±0.1 bx	66.72±0.1 ay	20.13±0.1 az
Merja Zerga	Winter	14.50±0.1 ax	254.25±0.1 ay	47.15±0.1 az
	Spring	179.25±0.1 ax	33.1±0.1 ay	156.25±0.1 az
	Summer	23.22±0.1 ax	10.94±0.1 ay	229.25±0.1 az
	Automn	128.75±0.1 bx	26.35±0.1 ay	13.01±0.1 az

Different labels (a, b) within a row indicate significant differences among Tissues at each season; different labels (x, y, z) within a column indicate significant differences among tissues at each site (p<0.05).

The differences between mean metal concentrations from both sites were statistically not significant, but the differences between tissues for same metal were statistically significant at each site ($p<0.05$) and no difference between seasons except Autumn, Blue crab gill indicated higher levels of all metals than in the other tissues, metal concentrations of tissues were higher in Autumn and summer and lower in winter. The order of metal concentration in C. sapidus tissues was Fe> Al> Mn> Zn > Cu > Pb > Cr> Cd> Ni. Gills are an important organ of interest in terms of their ability to uptake heavy metals from the water due to the metal binding sites located at the tissue's surface **(Wang and Rainbow, 2008)** these areas and supply valuable information about metal contents in tissues of the crabs from target sites indirectly indicate the environmental contamination of the lagoon. Chromium concentrations in gill tissue of crabs ranged from (0.07µg/g) to (7.37 µg/g) in Merja Zerga and (0.13 µg/g) to (8.61 µg/g) in Canal Nador, while concentrations in hepatopancreas were (0.20 µg/g) to (2.22 µg/g) in Merja Zerga and (0.09 µg/g) to (0.57 µg/g) in Canal Nador and le Chromium concentrations in muscle in Merja zerga were observed to be (0.15 µg/g) to (5.22 µg/g) in Merja Zerga and (0.13 µg/g) to (2.92 µg/g) in Canal Nador , the concentrations measured in both sites were higher than the recommendations of the world Health organization (WHO) **OMS (2006)** and the legal values for fish and fishery products proposed by **Nauen (1983)**, a maximum limit for heavy metal in edible wet mass of Cr is 1 µg/g but lower than a Guide for the control of molluscan shellfish **ISSC (2011)** with a maximum concentration 12 µg/g . In the absence of activities using Cr in its different forms in the region, it seems that its origin is the contributions of the sebou basin known for its tanneries (Fes, Kenitra) **(Fekhaoui, 1990; Fekhaoui *et al.*, 1993)** and their routing to Nador canal to the lagoon of Moulay bousselham (Merja zerga). Muscle tissue is commonly regarded to have low accumulation ability for heavy metals **Tapia *et al.*, (2012)**; Muscle, gill and hepathopancreas concentrations of chromium in blue crabs in our study were generally higher than those reported for Iskenderun Bay **Türkmen *et al.*, (2006)**, canal adjacent to Lae Drive, runaway bay **(Mortimer and Cox, 1999)**, Ojo Rivers **Ayejuyo *et al.*, (2009); Olowu *et al.*, (2010)**, Mediterranean Lagoons **Cengiz *et al.*, (2011)** and in the Köyceğiz Lagoon System **(Genç and Yilmaz, 2017)**. Zinc concentrations in gill of crabs ranged from (69.7µg/g) to (149.9 µg/g) in Merja Zerga and (72.7 µg/g) to 125. 62 µg/g) in Canal Nador. While concentrations in hepatopancreas were (81.3 µg/g) to (137.77µg/g) in Merja zerga and (68.82µg/g) to (136.07µg/g) in Canal Nador and the Zinc concentrations in muscle in Merja zerga were observed to be (78.55 µg/g) to(135.7µg/g) and (79.87µg/g) to (168.82µg/g) in Canal nador. The concentrations quantified in both sites were higher than the European Union **EU (2006)**, a maximum limit for Zn is 50 mg/kg, for **FAO and WHO (2011)** is 1 mg/kg, **Nauen (1983)** is (30 µg/g -100 µg/g), and Turkish acceptable limits for fishery products **TKB (2002)** the maximum limit is 50 µg/g, its presence is due to a thrust importance of this element by the descending waters in the direction of the sea **Fekhaoui *et al.*, (2009)**. In comparison of metal with other research for example for canal adjacent to Lae Drive, runaway bay **(Mortimer and Cox, 1999)** the concentration is (63.1 µg/g - 83.4 µg/g) in muscles lower than our study, in Ojo Rivers the concentration is 8.31 µg/g to 16.2 µg/g (29) and in the other research the concentrations were 0.024 µg/g to 6.06 µg/g **Olowu *et al.*, (2010)**, in River Aponwe the concentration is 5 µg/g **(Falusi and Olanipekun, 2007)**, in the medierannean Lagoons **Cengiz *et al.*, (2011)** and in the Köyceğiz Lagoon System **(Genç and Yilmaz, 2017)**. Lead concentrations in gill of crabs ranged from (0.36 µg/g) to (27.1µg/g) in Merja zerga and (0.67µg/g) to 34.35µg/g) from Canal Nador is higher than Köyceğiz Lagoon System in Turkey **(Genç and Yilmaz, 2017)** and in Mouth of river Segura in Spain **Inmaculada *et al.*, (2020)** and lower than Mersin bay in turkey Çoğun et al. (2017), While concentrations in hepatopancreas were (0.56 µg/g) to (1.13 µg/g) in Merja zerga and (0.35µg/g) to (0.64µg/g) in canal Nador were lower than Mersin bay in turkey **(Çoğun *et al.*, 2017)**, Köyceğiz Lagoon System in turkey **(Genç and Yilmaz, 2017)** and in Pensacola Bay in USA **Karouna-Renier *et al.*, (2007)** but higher in Mouth of river Segura in Spain **El Abidi *et al.*, (2010)**. and the lead concentrations in muscle in Merja Zerga were observed to be (0 µg/g) to (11.92µg/g) in Merja zerga and (0 µg/g) to (20.35 µg/g) in Canal Nador were higher than Iskenderun Bay Türkmen *et al*. (2006), Mediterranean coastal **Cengiz *et al.*, (2011)** Mersin Bay in turkey Çoğun et al. (2017) also in Atlantic coast of Florida in USA **(Adams and Engel, 2014)**, in Acquatina Lagoon in Italy **Zotti *et al.*, (2016)** and in Mouth of river Segura in Spain **El Abidi *et al.* (2010)**.

The concentrations identified in all tissues muscles Gills and hepathopancreas were higher than European union **EU (2006)** when the maximum limit for lead is 0.5 µg/g and for FAO/WHO is 0.3 µg/g **FAO and WHO (2011)**. The essential source of this non-essential element is the use of leaded gasoline before 2010 **El Abidi *et al.*, (2010)**, and also the presence of pesticides and agricultural inputs used for rice cultivation and other crops that threaten the ecological balance of the site **Madigosky *et al.*, (1991).** Nickel concentrations in gill of crabs ranged from (0.14µg/g) to (2.88µg/g) in Merja zerga and (0.39µg/g) to (3.77µg/g) in Canal Nador. While concentrations in hepatopancreas were (0.35µg/g) to (1.36µg/g) in Merja zerga and (0.61µg/g) to (2.35 µg/g) in Canal Nador and the nickel concentrations in muscle in Merja zerga were observed to be (0.33µg/g) to (2.44µg/g) and (0.6µg/g) to (2.05µg/g) in Canal Nador. Nickel levels of this study were higher than those reported for canal adjacent to Lae Drive, runaway bay **(Mortimer and Cox, 1999)**, Mediterranean Lagoons **Cengiz *et al.*, (2011)**, River Aponwe **(Falusi and Olanipekun, 2007)** and the I˙skenderun Bay **Türkmen *et al.*, (2006).** The concentrations measured in our study were lower than Guide for the control of molluscan shellfish ISSC the maximum limit is (70 µg/g). Cadmium concentrations in gill of crabs ranged from (0.64 µg/g) to (1.28 µg/g) in Merja zerga and (0.79 µg/g) to (1.24 µg/g) in canal Nador compared to other research in different countries and locations the concentrations in our study were higher than Köyceğiz Lagoon System **(Genç and Yilmaz, 2017)** and in Mediterranean coastal in turkey **Cengiz *et al.*, (2011)** but lower in Mersin Bay in turkey Çoğun et al. (2017), while concentrations in hepatopancreas were (0.56 µg/g) to (1.13µg/g) in Merja zerga and (0.6 µg/g) to (4.24 µg/g) in canal Nador were lower in Mersin Bay in turkey Çoğun et al. (2017) and higher in Köyceğiz Lagoon System **(Genç and Yilmaz, 2017)**, in Mouth of river Segura in Spain **Inmaculada *et al.*, (2020)** and in Pensacola Bay in USA **Karouna-Renier *et al.*, (2007)** and the cadmium concentrations in muscle in Merja zerga were observed to be (0.1µg/g) to (1.34µg/g) and (0.57µg/g) to (1.22µg/g) in canal Nador, higher than those in Iskenderun Bay, Mediterranean coastal, Mersin Bay in turkey , Acquatina Lagoon in Italy, Atlantic coast of Florida and Pensacola Bay in USA, although cadmium concentrations measured in the muscles of blue crab in our study were higher than **ISSC (2011)**, **TKB (2002)** and **Nauen (1983)**. Manganese concentrations in gill of crabs ranged from (3.07µg/g) to (136.72µg/g) in Merja zerga and (3.58µg/g) to (204.42 µg/g) in Canal Nador were higher than values mentioned in the Mediterranean Lagoons **Cengiz *et al.*, (2011)**. While concentrations in hepatopancreas were (6.73 µg/g) to (58.22 µg/g) in Merja zerga and (6.21µg/g) to (33.9 µg/g) in Canal nador and the manganese concentrations in muscle in merja zerga were observed to be (3.12 µg/g) to (245.95 µg/g) and (4.21 µg/g) to (141.25 µg/g) in canal Nador were higher than those reported in canal adjacent to Lae Drive, runaway bay **(Mortimer and Cox, 1999)**, I˙skenderun Bay Türkmen et al. (2006) and in the Mediterranean Lagoons **Cengiz *et al.*, (2011)**.

Iron concentrations in gill of crabs ranged from (47.2µg/g) to (530.25 µg/g) in Merja zerga and **(Cengiz *et al.*, 2011)** 9µg/g to 380.75µg/g) in Canal nador were higher than research in the Mediterranean Lagoons **Cengiz *et al.*, (2011)**, While concentrations in hepatopancreas were (42.07µg/g) to

(354.75µg/g) in Merja zerga and (39.3µg/g) to (413.55µg/g) in canal nador and the Iron concentrations in muscle in Merja zerga were observed to be (38.56µg/g) to (656 µg/g) and (57.85µg/g) to (430.5µg/g) in canal Nador higher than concentrations in canal adjacent to Lae Drive, runaway bay **(Mortimer and Cox, 1999)**, in I˙skenderun Bay **Türkmen et al., (2006)** and the Mediterranean Lagoons **Cengiz *et al.*, (2011)**.

Copper concentrations in gill of crabs ranged from (46.5µg/g) to (138.17µg/g) in Merja zerga and (45.97µg/g) to (166.22µg/g) in canal nador were higher than the Köyceğiz Lagoon System in turkey **(Genç and Yilmaz, 2017)**, Mediterranean Lagoons **Cengiz *et al.*, (2011)**, while concentrations in hepatopancreas were (45.62µg/g) to (133.85µg/g) in Merja Zerga and (1.71µg/g) to (141.4µg/g) in Canal Nador also were higher than the Köyceğiz Lagoon System in turkey **(Genç and Yilmaz, 2017)** and Copper concentrations in muscle in Merja zerga were observed to be (44.55µg/g) to (156.62µg/g) in Merja Zerga and (22.62µg/g) to (155.4µg/g) in Canal Nador were higher than those in in canal adjacent to Lae Drive, runaway bay **(Mortimer and Cox, 1999)**, in I˙skenderun Bay **Türkmen *et al.*, (2006)** and the Mediterranean Lagoons **Cengiz *et al.*, (2011)**. The concentrations measured in both sites were higher than the Turkish acceptable limits for fishery products with a maximum limit for Cu is 20 µg/g **TKB (2002)**, European union is 5 mg/kg **EU (2006)** and for Nauen CE is (10 µg/g -100 µg/g) **Nauen (1983)**, the activities identified in drainage areas, particularly rice users of copper sulphate can explain the highest concentrations in this locations **(Kucykbay and Orun, 2003); Antonin *et al.*, (2010)**. Aluminum concentrations in gill of crabs ranged from (14.50µg/g) to (179.25µg/g) in Merja zerga and (9.30µg/g) to (230µg/g) in canal Nador were higher than the Mediterranean Lagoons **Cengiz *et al.*, (2011)**. While concentrations in hepatopancreas were (10.94µg/g) to (254.25µg/g) in Merja Zerga and (10.94µg/g) to (66.72µg/g) in Canal Nador and the aluminum concentrations in muscle in Merja zerga were observed to be (13µg/g) to (229.25µg/g) in Merja Zerga and (20.13µg/g) to (254 µg/g) in Canal Nador were higher than ˙skenderun Bay in Turkey Türkmen et al. (2006) and in the Mediterranean Lagoons **Cengiz *et al.*, (2011)**.

CONCLUSION

The present study is the first for The Atlantic blue crabs caught from Merja Zerga and Nador canal in Morocco, blue crabs are contaminated with all metals. Generally, it was observed that the contamination levels in muscle tissues of crabs are higher than limit levels in all seasons, results showed that metal concentrations were lowest in muscle than in gill and hepathopancreas, can be used to understand the chemical quality of crabs and confirmed the usefulness of C.sapidus for practical field monitoring of metal contamination at a local scale. this invasive species could become an important source of environmental data from this particular ecosystem and makes a point that all metal levels are higher than the acceptable values for human consumption set by various health organizations.

REFERENCES

Çoğun, H.Y.; Firat, Ö. ; Aytekin, T.; Firidin, G. ; Firat, Ö. ; Varkal, H. ; Temiz, Ö. and Kargin, F. (2017). Heavy Metals in the Blue Crab (Callinectes sapidus) in Mersin Bay, Turkey. Bull Environ Contam Toxicol 98:824–829.

Ansari, TM ; Marr, I.L. and Tariq, N. (2004). Heavy metals in marine pollution perspective-a mini review. J Appl Sci. 4: 1-20. [Google Scholar].

Freeman, O. E. and Olomukoro J. O. (2017). Heavy Metal Bioaccumulation in Periwinkle

(Tympanostomus Spp) and Blue Crab (Callinectes amnicola) Harvested from a Perturbed Tropical Mangrove Forest in the Niger Delta, Nigeria. Journal of Agriculture and Ecology Research International 11(1): 1-12.

Chou, C.L.; Paon, L.A. and Moffatt, J.D. (2002) Cadmium, copper, manganese, silver, and zinc in rock crab (Cancer irroratus) from highly copper contaminated sites in the Inner Bay of Fundy, Atlantic Canada. Bull Environ Contam Toxicol 68:885–892. doi:10.1007/ s00128-002-0037-2.

Türkmen, A.; Türkmen, M.; Tepe, Y.; Mazlum, Y. and Oymael, S. (2006) Metal concentrations in blue crab (Callinectes sapidus) and mullet (Mugil cephalus) in Iskenderun Bay, Northern East Mediterranean, Turkey. Bull Environ Contam Toxicol 77:186–193. doi:10.1007/s00128-006-1049-0.

Saadatia, M.; Soleimania, M.; Sadeghsabab M. and Hemami, M. R. (2019). Bioaccumulation of heavy metals (Hg, Cd and Ni) by sentinel crab (Macrophthalmus depressus) from sediments of Mousa Bay, Persian Gulf. Ecotoxicology and Environmental Safety.

Naczk, M.; Williams J.; Brennan, K.; Liyanapathirana, C. and Shahidi F.(2004) Compositional characteristics of green crab (*Carcinus maenas*). Food Chemistry, 88:429-434.

Alibabić, V.; Vahčić, N.; Bajramović, M. (2007) Bioaccumulation of metals in fish of salmonidae family and the impact on fish meat quality. Environ Monit Assess 131(1):349–364.

Burger,J.; Gochfeld, M.;Jeitner, C.; Burke, S. and Stamm, T. (2007) Metal levels in flathead sole (Hippoglossoides elassodon) and great sculpin (Myoxocephalus polyacanthocephalus) from Adak Island, Alaska: potential risk to predators and fishermen. Environ Res 103(1):62–69.

Jop, K. M.; Biever, R. C. J. R. and Hoberg, S. P. (1997). Analysis of Metals in Blue Crabs, from Two Connecticut Estuaries, Callinectes sapidus. Bull. Environ. Contam. Toxicol. (1997) 58:311–317.

Kumar, M.; Ferguson, G.; Xiao, Y.; Hooper, G. and Venema, S. (2000). Studies on reproductive biology and distribution of blue swimmer crab (Portunus pelagicus) in South Australian Waters. Research report series, 47: 1324-2083.

Reinecke, A.J.; Snyman, R.G. and Nel, J.A.J. (2003). Uptake and distribution of lead (Pb) and cadmium (Cd) in the freshwater crab, Potamonautes perlatus (Crustacea) in the Eerste River, South Africa. Water Air Soil Pollution, 145: 395-408.

Jessica, M.; Reichmuth, Peddrick, Weis. and Judith, S. W. (2010). Bioaccumulation and depuration of metals in blue crabs (Callinectes sapidus Rathbun) from a contaminated and clean estuary. Environmental Pollution 158 (2010) 361–386.

Benhoussa, A.; Qninba, A.; El Agbani, A.; Hammada, S.; Bazairi, H. and Fekhaoui, M. (2003). Fiche descriptive sur les zones humides Ramsar.

El Qoraychy, I.; Fekhaoui, M.; El Abidi, A and Yahyaoui, A. (2015). Biometry and demography of Procambarus clarkii in Rharb Region, Morocco. Aquaculture, Aquarium, Conservation & Legislation International Journal of the Bioflux Society. AACL Bioflux, Volume 8, Issue 5. http://www.bioflux.com.ro/aacl.

Fraikech, M.; Berraho, A.; Ramdani, M.; Chafik, A.; Serghini, M. and Moukrim, A. (2005). Evolution spatio-temporelle des dinoflagellés dans la baie d‟Agadir Maroc. Mar Life, 15: 19-27.

Wang, WX. and Rainbow, P.S. (2008). Comparative approaches to understand metal bioaccumulation in aquatic animals. Comp Biochem Physiol 148:315–323)

OMS and World health organization; (2006). International program on chemical safety. Environmental criteria.

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

ISSC (2011) Guide for the control of molluscan shellfish, 2007 Revision (Printed March 2009). http://www.issc.org. Accessed01 March 2011

Fekhaoui, M. (1990). Hydrological research on the middle sebou subject to discharges from the city of FES; monitoring of macro-pollution and assessment of its impact on physical, chemical and biological components of the ecosystem. Univ. Mohammad V,Fac.sci., Rabat. State doctorate thesis.p.173.

Fekhaoui, M.; Abou Zaid, H and Foutlane, A. (1993). Study of contamination metallic sediments and algae from the sebou subject to discharges from the city of Fes (Morocco). Bull. inst sci Rabat; 17:13-20.

Tapia, J.; Vargas-Chacoff, L.; Bertran, C.; Pena-Cortes, F.; Hauenstein, E.; Schlatter, R.; Jimenez, C. and Tapia, C. (2012). Heavy metals in the liver and muscle of Micropogonias manni fish from Budi Lake, Araucania Region, Chile: potential risk for humans. Environ Monit Assess 184:3141–3151.

Mortimer, MR and 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

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

Olowu, R.A.; Ayejuyo, O.O.; Adejoroi, A.; Adewuyi, G.O.; Osundiya, M.O.; Onwordi, C.T.; Yusuf, K.A and Owolabi, M.S. (2010). Determination of heavy metals in crab and prawn in Ojo Rivers Lagos, Nigeria E-J Chem 7:526–530.

Cengiz, M.; Tu¨rkmen, M.; Tu¨rkmen, A. and Tepe, Y. (2011). Comparison of Metal Concentrations in Tissues of Blue Crab, Callinectes sapidus from Mediterranean Lagoons. Bull Environ Contam Toxicol (2011) 87:282–286.

Okan, G.T and Yilmaz, F. (2017). Metal Accumulations in Water, Sediment, Crab (Callinectes sapidus) and Two Fish Species (Mugil cephalus and Anguilla anguilla) from the Köyceğiz Lagoon System–Turkey: An Index Analysis Approach. Bull Environ Contam Toxicol 99:173–181.

EU, (2006). Maximum levels for certain contaminants in foodstuffs, Official Journal of the European Union L 364/5

FAO/WHO (2011). Expert Committee on Food Additives. Evaluation of certain food additives and contaminants: Seventy-third report of the Joint FAO/WHO Expert Committee on Food Additives, WHO Technical Report Series 960, 228.

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

Fekhaoui, M.; Elblidi S., Serghini, A. and El Abidi, A. (2009). The biological reserve of Merja Zerga and its immediate environment: hydrology and assessment of impacts of the use of inputs (fertilizers and pesticides).

Falusi, B.A.; Olanipekun, E.O. (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.

Salvat-Leal, I.; Verdiell, D.; Parrondo, P.; Barcala, E and Romero, D. (2020). Assessing lead and cadmium pollution at the mouth of the river Segura (SE Spain) using the invasive blue crab (Callinectes sapidus Rathbun, 1896, Crustacea, Decapoda, Portunidae) as a bioindicator organism. Regional Studies in Marine Science 40. 101521.

Karouna-Renier, N.K.; Snyder, R.A.; Allison, J.G.; Wagner, M.G. and Ranga Rao, K. (2007). Accumulation of organic and inorganic contaminants in shellfish collected in estuarine waters near Pensacola, Florida: contamination profiles and risks to human consumers. Environ. Pollut. 145 (2), 474–488

El Abidi, A.; Fekhaoui, M.; Ghouli, A.; Pier Vittori, R. and Yahyaoui, A. (2010). Use of pigeons as bioindicator of air pollution from heavy metals at Rabat-Sale Morocco Avocetta 34:29-34.

Madigosky, S. R.; Alvarez-Hernandez, X. and Glass, J. (1991). Lead, cadmium, and aluminum accumulation in the red swamp crayfish Procambarus clarkii G. collected from roadside drainage ditches in Louisiana. Archives of environmental Contamination and Toxicology, 20, 253–258.

Adams, D.H. and Engel, M.E. (2014). Mercury, lead, and cadmium in blue crabs, Callinectes sapidus, from the Atlantic coast of Florida, USA: a multipredat approach. Ecotoxicol. Environ. Saf. 102, 196–201.

Zotti, M.; Del Coco, L.; De Pascali, S.A.; Migoni, D.; Vizzini, S.; Mancinelli, G and Fanizzi, F.P. (2016). Comparative analysis of the proximate and elemental composition of the blue crab Callinectes sapidus, the warty crab Eriphia verrucosa, and the edible crab Cancer pagurus. Heliyon 2 (2), e00075.

Kucykbay, F.z. and Orun, I. (2003). Copper and zinc accumulation in tissues of the freshwater fish Cyprinus carpio collected from the Karakaya Dam Lake, Malatya (Turkey). Fresenius Environ Bull, 12:62-66.

Antonin, K.; Milos, B. and Pavel, K. (2010). Bioaccumulation and Effects of Heavy Metals in Crayfish: Review. Water Air Soil Poll, 211: 5-16.