STUDY ON SOME HAZARDOUS ELEMENT RESIDUES IN FRESH WATER CRAYFISH (*PROCAMBARUS CLARKII*) IN RELATION TO PUBLIC HEALTH

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Abstract

A total of 24 surface water samples and 24 muscle samples of fresh water crayfish *Procambarus clarkii* were collected from two villages in Zagazig district, Sharkia governorate for detection and determination of Cd, Pb, Cu, Zn, Hg and Ni by using Atomic Absorption Spectrophotometer. The obtained results revealed that the mean values of cadmium, lead, copper, zinc and mercury in water samples were 0.134, 1.377, 0.029, 0.118 and 0.262 ppm, respectively, while, the average residues of the same metals in crayfish muscle samples were 2.852,11.602, 9.905, 6.434 and 2.519 ppm, respectively. On the other aspect, nickel could not be detected in all examined water and crayfish muscle samples.

All the examined water samples had cadmium, lead and mercury in levels exceeded the permissible limits recommended by WHO (1984). On the other hand, copper and zinc levels were below the permissible limits in all examined water samples. Meanwhile, all examined crayfish muscle samples had cadmium and lead levels above the permissible limits, while, 23 (95.8%) of these samples contained mercury levels higher than the permissible limits recommended by FAO/WHO (1992) and E.O.S.Q.C. (1993). Copper and zinc residues were below the permissible limits in all examined muscle samples.

From afore mentioned results, it can be concluded that the examined water and crayfish muscles were obviously contaminated by cadmium, lead and mercury. So, from the public health point of view, consumption of crayfish muscles constitutes a public health hazard. Otherwise, copper and zinc residues were found in relatively low levels which could not conduct any hazardous effect on public health .

INTRODUCTION

Fresh water crayfish *Procambarus clarkii* appeared at the last few years in rural areas of Egypt . This fish was one of the lower cost protein sources . So ,it was used as a food and eaten during a rather long season starting from May to October. During this season , rural peoples consume large quantities of this kind of fish .

Environmental contamination by metals such as cadmium , lead ,copper , zinc , mercury and nickel were generally reflected by an increase in tissue residues of fish . This is also true for fresh water crayfish as reported by Bagatto and Alikhan (1987) . Moreover in many surveys ,crayfish have been used as an indicator of metal pollution in the aquatic environment (Jorhem *et al.* ,1994).

In spite of many studies in Egypt recorded on considerable levels of different element residues in water streams (Abel-Nasser *et al.* , 1996 and Daoud *et al.* ,1999), the reports on metal residues from field collection crayfish in Egypt were rare . Therefore , this study is planned to determine element residues in both edible tissues of crayfish samples and fresh water which contained this fish .On the other hand , this investigation threw light upon the quality of crayfish muscles for human consumption concerning element residues .

MATERIALS AND METHODS

Twenty-four water and 24 crayfish *Prcombarus clarkii* samples were collected from fresh water streams in two villages (El- shobak and El-karakra) near Zagazig city , during summer 2002 for detection and determination of element residues .

I Analysis of elements in water samples

1-Collection and preparation of samples

The technique of water sampling and preparation was conducted as recommended by A.P.H.A. (1985) . Water samples were collected from fresh water streams by using one liter glass bottle for each sample . Water samples were filtered through 0.45 μm Watman membrane filter and acidified by addition of 3 ml of aqueous solution of nitric acid (1:1) per liter of water . All samples were stored at 4^{O} C until analysis .

2-Quantitative determination of metals

Quantitative determination of cadmium , lead ,copper ,zinc and nickel was conducted by using UNICAM 969 Atomic Absorption Spectrophotometer, while, mercury was determined by using Perkin –Elmer mod. 2830, USA, Spectrophotometer. The concentrations of elements in the examined water samples were taken directly from digital scale reading of Atomic Absorption Spectrophotometer .

II) Analysis of elements in muscles of crayfish samples

1-collection and preparation of samples

Crayfish samples which were collected from fresh water streams were killed, placed in polyethylene bags and kept frozen till analysis was carried out. Crayfish tissue samples were prepared according to the method described by Al-Ghais (1995) . One gram of muscle tissues was transferred to a clean screw capped bottle and digested with 10 ml solution of nitric/perchloric acid (4:1) . Initial digestion was made for 4 hours at room temperature , followed by heating at 40-45 °C for one hour in water bath ,then, temperature was raised to 75 °C until the end of digestion . After cooling at room temperature , the cold digest was diluted to 20 ml with deionized water and filtered through 0.45 μ m Watman filter paper . The clean filtrate of each sample was kept in refrigerator to avoid evaporation .

2-Preparation of blank solution

Blank solution was prepared to check the possible trace of metals that may be present in acids and deionized water used in the preparation , digestion and dilution of tissue samples.Ten ml solution of nitric/perchloric acid (4:1) were put in screw capped bottle and exposed to the same digestion , dilution and filtration procedures used for tissue samples .

Table 2. Frequency distribution of elements in all examined water and crayfish muscle samples collected from fresh water streams.

Elements	Water (n = 24)					Crayfish muscles (n = 24)				
	Permissible limits	Within permissible limits		Over permissible limits		Permissible limits	Within permissible		Over permissible limits	
		No.	%	No	%		No	%	No	%
Cadmium	0.005 ppm (1)	0.0	0.0	24	100	0.05 ppm(2)	0.0	0.0	24	100
						0.1 mg/kg(3)	0.0	0.0	24	100
						1.0 µg/g(4)	2	8.33	22	91.66
Lead	0.050 ppm (1)	0.0	0.0	24	100	0.5 ppm(2)	0.0	0.0	24	100
						0.1 mg/kg(3)	0.0	0.0	24	100
						5.0 µg/g(4)	0.0	0.0	24	100
Copper	1.00 ppm (1)	24	100	0.0	0.0	20 ppm(4) (5)	24	100	0.0	0.0
Zinc	5.00 ppm (1)	24	100	0.0	0.0	50 ppm(5)	24	100	0.0	0.0
Mercury	0.001 ppm (1)	0.0	0.0	24	100	0.5 ppm(2) (3)	1	4.16	23	95.83
						1.0 µg/g(4)	2	8.33	22	91.66

(1) WHO (1984)
(2) FAO/WHO (1992)
(3) E.O.S.Q.C. (1993)
(4) Boletin Oficial del Estado, Spain (1991), In: Daoud et al., (1999).
(5) Food Stuff: Cosmetics and Disinfectants (1972)

Table 3. Correlation coefficient of detected element residues in water stream samples with the same element residues in crayfish muscle samples.

Elements in water / Elements in tissues	Cadmium	Lead	Copper	Zinc	Mercury
Cadmium	0.9532**				
Lead		0.9127**			
Copper			0.8745**		
Zinc				0.9508**	
Mercury					0.8061**

** Highly significant at level ($P \leq 0.01$)

DISCUSSION

Regarding different element residues in water samples collected from fresh water streams, Table 1 revealed that the mean values of cadmium, lead, copper, zinc and mercury were 0.134 ± 0.0073, 1.377 ± 0.0651, 0.029 ± 0.0104, 0.118 ± 0.0078 and 0.262 ± 0.0542 ppm, respectively, while, nickel could not be detected in all examined water samples. These results nearly coincided with those obtained by Daoud *et al.* (1999). Meanwhile , Abd el Nasser *et al.* (1996) recorded similar levels of lead and copper in Nile river in Assuit governorate , but, they found lower concentrations of cadmium and mercury than those reported in the present study. Also, lower metal values in fresh water streams were recorded by Kurasaki *et al.* (2000).

On the other hand, Table 2 showed that all examined water samples had cadmium, lead and mercury concentrations above the permissible limits recommended by WHO (1984), otherwise, copper and zinc levels were below the permissible limits in all examined water samples

From the above mentioned data, it is clear that the fresh water streams contained crayfish contaminated by cadmium, lead and mercury. The hazardous elements reached the water streams through agricultural soil rich in heavy metals as a result of use various fungicides, herbicides, phosphate fertilizers, organic manure and the presence of decaying plant and animal residues. On the other aspect, the use of waste water irrigation, sewage sludge, phosphate fertilizers and grain disinfectant has further increased the quantity of different metals specially cadmium and mercury in agricultural soil. Lead accumulation has been attributed to the use of farm machinery runoff in agricultural areas (Ward *et al.*, 1978). From the above mentioned results, it was concluded that fresh water streams containing crayfish showed higher concentration of cadmium, lead, mercury and this may cause bioaccumulation of these elements in crayfish muscles.

Results recorded in Table 1 showed that the average concentrations of cadmium, lead, copper, zinc and mercury in crayfish muscle samples were 2.852 ± 0.2146, 11.602 ± 0.3745, 9.905 ± 0.6451, 6.434 ± 0.2856 and 2.519 ± 0.2688 ppm respectively, as recorded in water stream samples, nickel residues could not be detected in all examined crayfish muscle samples. In the present study, cadmium and lead residues detected in crayfish muscles were obviously higher than those found by Rincon-Leon *et al.* (1988) in Spain, Finerty *et al.* (1990) , in U.S.A, and Jorhem *et al.*, (1994) in Sweden. Moreover, Bagatto and Alikhan (1987) in Canada recorded cadmium residues in crayfish muscles lower than those in the current study. In Egypt, cadmium and lead residues in fresh water fish muscles obtained by Daoud *et al.* (1999) were nearly similar to those reported in the present investigation. On the other hand, the present copper levels in crayfish muscles were parallel to those recorded by Bagatto and Alikhan (1987), Jorhem *et al.* (1994) and Daoud *et al.* (1999) who found that copper in Egyptian fresh water fish was 0.117-8.2 ppm. Meanwhile, Jorhem *et al.* (1994) and Daoud *et al.* (1999) recorded zinc levels higher than the figures in muscle of Sweden crayfish and Egyptian fresh water fish, respectively. Concerning mercury residues, Daoud *et al.* (1999) and Storelli and Marcotrigino (2001) detected mercury residues in muscles of fresh water fish with lower levels than those obtained in the present study.

Table 2 indicates that all crayfish muscle samples had cadmium and lead above the permissible limits recommended by FAO/WHO (1992), Egyptian Organization for Standardization and Quality Control E.O.S.Q.C. (1993). On the other aspect, all examined crayfish muscle samples had copper and zinc below the permissible limits showed in Table 2. Only one (4.16%) out of 24 crayfish muscle samples had mercury below the permissible limits recommended by FAO/WHO (1992) and E.O.S.Q.C. (1993).

Table 3 showed highly significant positive correlation ($P \leq 0.05$) between different element residues in water samples and the same element residues in crayfish muscle samples. This result agreed with that found by Naqvi and Howell (1993) who reported that crayfish can be used for monitoring of heavy metal contamination in aquatic ecosystem, due to their ability to accumulate and retain them rapidly in their tissues for a long period of time. Rapid accumulation of cadmium in crayfish could also be due to the presence of cadmium binding proteins in the mid-gut of *Procambarus clarkii* (Lyon, 1984) .

From aforementioned results, the obviously contamination of crayfish muscles by cadmium, lead and mercury was highly expected because these elements exceeded the permissible limits in all examined water samples. It is evident from these results that cadmium, lead and mercury were the most predominant toxic elements constituting a hazardous effect on human through consumption of crayfish muscles. The chronic cadmium toxicity included kidney damage with proteinurea, impaired regulation of calcium and phosphates, manifesting bone demineralization, osteomalacia and pathological fractures (Friberg and Elinder, 1985). On the other hand ,lead inhibits biosynthesis of heme and thereby, affects the membrane permeability of kidney, liver and brain cells which reduces their function or completely breakdown of these tissues (Forstner and Wittmann, 1983). Regarding mercury as chronic toxicity, it is accumulative poison because of the high affinity of tissue to it (Daoud, 1999), Mercury poisoning is responsible for neurological damage, loss of vision, paralysis and death, it also passed through placenta, causing chromosomal disorder and teratogenicty (Sorensen, 1991). In spite of copper and zinc detected in safety levels in crayfish muscles and nickel could not be detected, these elements can exhibit serious hazardous effects on human health if accumulated in levels exceeding the permissible limits.

From this work, it can be concluded that crayfish muscles suffered from contamination with cadmium, lead and mercury due to pollution of water streams. On the other aspect, continual increase in the number of industrial and agricultural processes produces these pollutants and participates in increasing the incidence of some chronic diseases. To throw some light on scientific solution of the problem, in order to minimize the effect of these pollutants, the following recommendations should be applied:

1- Recycling of industrial effluents as well as hygienic disposal and treatment of sewage wastes are recommended.
2- Application of phosphate fertilizers and sewage sludge should be kept under control.
3- A regular and representative monitoring of different elements in fresh water crayfish is recommended. Moreover, this fish can be used as an indicator of aquatic pollution.
4- Under the present levels of metal pollution, spread consumption of fresh water crayfish muscles is not recommended.

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دراسة عن متبقيات بعض العناصر الضارة فى إستاكوزا المياه العذبة وعلاقتها بالصحة العامة

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أجريت هذه الدراسة لقياس متبقيات عدد من العناصر فى عضلات سمك الكرى (إستاكوزا المياه العذبة) وكذلك قياس تلك العناصر فى المجارى المائية التى يعيش فيها هذا الحيوان. تم أخذ ٢٤ عينة مياه وكذلك ٢٤ عينة من سمك الكرى (إستاكوزا المياه العذبة) وتم تجميع العينات من قريتى الشوبك والقراقرة وهما من القرى التابعة لمدينة الزقازيق، وقد تم إعداد العينات وقياسها بجهاز الامتصاص الذرى وقد أسفرت الدراسة عن النتائج التالية، وجد أن متوسط تركيزات الكادميوم، الرصاص، النحاس، الزنك والزئبق فى عينات المياه كان كالآتى ٠,١٣٤، ١,٣٧٧، ٠,٠٢٩، ٠,١١٨، ٠,٢٦٢ جزء فى المليون على التوالى فى حين كان متوسط تركيزات نفس هذه العناصر فى عضلات سمك الكرى (إستاكوزا المياه العذبة) ٢,٨٥٢، ١١,٦٠٢، ٩,٩٠٥، ٦,٤٣٤، ٢,٥١٩جزء فى المليون، من ناحية أخرى لم يتواجد النيكل فى جميع عينات المياه والأنسجة التى تم قياسها فى هذه الدراسة.

أوضحت النتائج أن جميع عينات المياه المختبرة كانت تحتوى على كادميوم، رصاص وزئبق بتركيزات أعلى من الحدود المسموح بها من منظمتى الأغذية والزراعة والصحة العالمية سنة ١٩٨٤ م وخلافاً لذلك كانت كميات النحاس والزنك أقل من المسموح به فى المياه. أما عينات عضلات سمك الكرى (إستاكوزا المياه العذبة) فقد احتوت كلها على كادميوم ورصاص وزئبق بتركيزات أعلى من المسموح بها من قبل منظمتى الأغذية والزراعة والصحة العالمية عام ١٩٩٢م وكذلك وزارة الصناعة المصرية عام ١٩٩٣م فيما عدا عينة واحدة كان بها زئبق أقل من الكميات المسموح بها، أما النحاس والزنك فقد وجدا بكميات أقل من المسموح بها فى جميع عينات العضلات.

من النتائج السابقة نستخلص أن سمك الكرى (إستاكوزا المياه العذبة) وكذلك المياه التى تعيش فيها تعانى من التلوث بالكادميوم والرصاص والزئبق، ولذلك فإن استهلاك لحوم هذا الحيوان تنطوى على مخاطر صحية قد تضر بالمستهلك وعلى هذا فإننا لا ننصح باستعمال سمك الكرى (إستاكوزا المياه العذبة) كطعام.