Chemical Science Review and Letters ISSN 2278-6783

Research Article

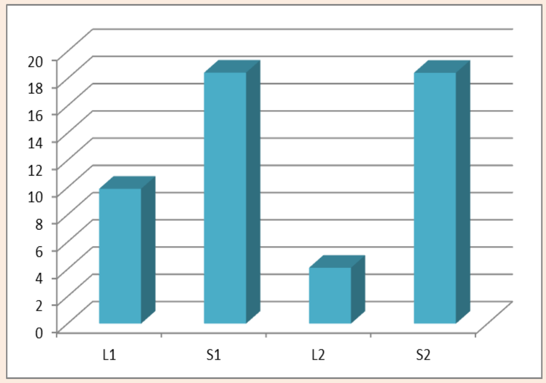
Determination of Mercury in Fish Flesh by Cold Vapor Atomic Absorption Spectrometry

Ali A. Ateeg and Ismat H. Ali*

Chemistry Department, College of Science, King Khalid University, Abha, Saudi Arabia, P.O. Box, 9004

Abstract

Two different fish species, (*LethrhrinidaeLethrinus*) and (*SerranusSubligarius*) consumed by Sudanese were collected from Red Sea coast of Portsudan and Suakin cities, Sudan. Samples were examined for analysis of mercury. The mercury concentrations in muscle samples were determined by cold vapor atomic absorption spectrophotometry (*CVAAS*). The mean concentration of mercury for *LethrinidaeLethrinus* was found to be 9.87ng/g in Portsudan city and 4.06ng/g in Suakin city but have the same value for *SerranusSubligarius*18.43 and 18.42ng/g in Portsudan and Suakin respectively. This study indicates that commonly consumed fish from Red Sea coast have concentrations of mercury below the permissible levels stated in the US FDA guidelines.



***Correspondence**
Ismat Hassan Ali
ismathassanali@hotmail.com

Keywords: mercury, fish flesh, Portsudan, Suakin, CVAAS

Introduction

Mercury is a dangerous xenobiotic, particularly its vapors and some of its water-soluble salts; one of its properties is the ability to accumulate in the internal organs of living organisms [1-3]. Lethal concentrations of mercury salt range from less than 0.1 ngml^{-1} to more than 200.0 ngml^{-1} for marine species and freshwater organisms. Therefore, routine monitoring and control of mercury are becoming increasingly important, especially in water system. Several analytical techniques such as spectrophotometry [4] inductively coupled plasma mass spectrometry (ICP-MS) [5] inductively coupled plasma atomic emission spectrometry (ICP-AES) [6] voltammetric [7], atomic fluorescence spectrometry (AFS) [8] and neutron activation analysis [9] have been developed for the determination of mercury. Nevertheless, cold vapor atomic absorption spectroscopy (CV-AAS) is the most widely used method due to its simplicity, relatively low cost of operation, high sensitivity and selectivity [10-12].

As it is known, fish has been one of the most common foods for human. The numbers of fish species are estimated to range between 15000 and 14000 [13]. Like other living organisms, fish contains most of the ninety naturally occurring elements, like carbon, hydrogen, nitrogen, oxygen and sulfur. Other elements like calcium, magnesium, phosphorus, sodium and chloride are also present in g/kg quantity. Among other elements, trace metals have great importance as indicators of pollution and mercury is one of them. The production of mercury in the world has decreased recently in the industrialized countries as people are getting aware of the toxicity and diseases caused by this metal. However, still a large portion of its production reaches the seas and oceans [14].Mercury has a tendency to accumulate in marine organisms and the cause of this accumulation in fishes is its peculiar property wherein it gets methylated by marine bacteria [15]. Exposure to methylmercury varies according to the characteristic amounts and types of fish consumed; about 95% of the methylmercury in humans is originated from the ingested fish.

Methylmercury is also readily absorbed through the skin and lungs. Once absorbed into the bloodstream, methylmercury enters the red blood cells. More than 90% of the methylmercury found in blood is bound to hemoglobin in red blood cells [16]. Some methylmercury is also bound to plasma proteins but the concentration in red blood is always higher than that in plasma protein. The mercury levels in fishes generally depends upon several factors, like the position of the fish in the food chain, size, [17]. Most species of fish in oceanic and seas waters contain about 150µg/kg of mercury.

Mercury contamination has reported in fish and other biota in different coastal areas [18-24], however, according to our knowledge, no species of fish in Sudan locations were investigated for mercury.

The aim of this study was to investigate the concentration of mercury in two fish species collected from coastal water of Portsudan and Suakin cities, Sudan. It is hoped that the results of this study will aid in generating data needed for the assessment of mercury intake from fish. Such data is needed for the development of consumption advisories for the general public.

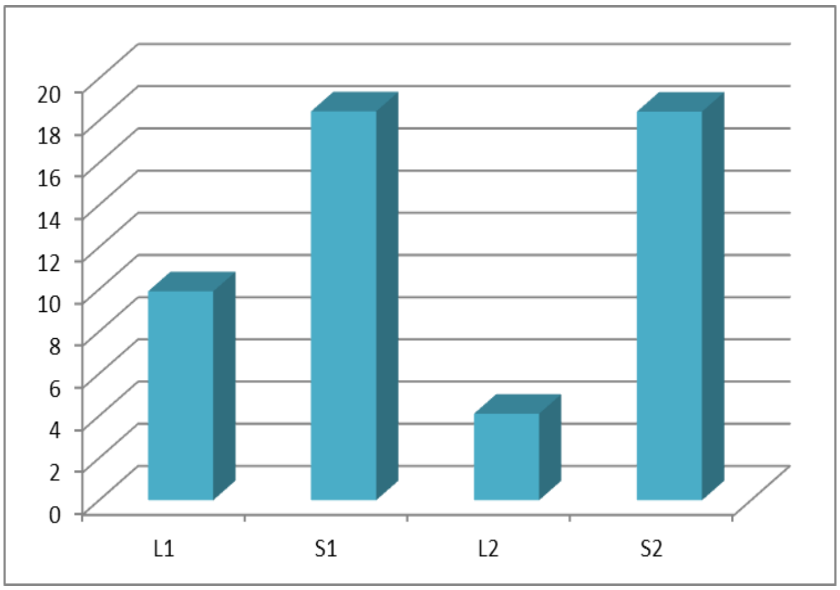


Figure 1 Mean concentrations of mercury in (ng/g) in two fish species

L1: LethrhrinidaeLethrinus in Portsudan, L2: LethrhrinidaeLethrinus in Suakin, S1: SeiramusSubligarius in Portsudan, S2: SeiramusSubligarius in Suakin

Experimental

Material and methods

All reagents were of analytical grade. Double distilled water was used in all experiments. The stock mercury solution was prepared by dissolving 0.1354g of $HgCl_2$ in 100ml 0.5MH_2SO_4, and dilute to 1liter(1ml=100mgHg^{2+}). The mercury working standard solutions prepared by diluting the stock solution (1.0ml=1µgHg^{2+}).The solution of1.5M hydroxylamine was prepared by dissolving 10.0g of hydroxylamine-hydrochloride($NH_2OH.HCl$) in100ml water, potassium permanganate solution(5%) and $SnCl_2$ solution(10%). A Shimadzu model 6300 atomic absorption spectrometer with standard cell 10cm long, having quartz winds was used for all absorbance measurements, mercury hallow cathode lamp discharge model(BGC-D2), air pump, mercury vapor unit (MVU).

Digestion Procedure

1.0g of fish sample was treated with 10.0ml H_2SO_4 and digested at 50-60^{0}C to wet -ash the sample. 3.0ml of hydrogen peroxide was added to completely decolorize the digestion mixture and the excess peroxide was removed by the addition of5% potassium permanganate until the solution retains purple color and the sample was diluted to 25.0ml. An appropriate aliquot was taken depending upon the concentration of mercury in the fish. 5.0ml of 1.5M hydroxylamine-hydrochloride was added and waited 30s for the solution to clear. 5.0ml of 10% $SnCl_2$ was added, waited 10s, and then aspirated with argon, and the maximum absorbance recorded.

Results and Discussion

In the present study, mercury concentration has been determined in two different fish species, *Lethrinidae Lethrinus* and *Serranus Subligarius*. Samples were collected from fish market of Suakin and Portsudan during summer 2010. Only the muscles were analyzed because mercury was reported to mainly accumulate in muscle tissues rather than other organs and tissues [25]. This may produce from the lipophilic character of methyl mercury, which is the main chemical form of mercury in fish.

The total mercury contents in the mentioned fish flesh of Portsudan and Suakin coast were found to be in the range of 1.59-35.76ng/g (for Portsudan city) and 3.83-32.08ng/g (for Suakin city), as shown in **Table 1**.

The species investigated and reported here differ in mercury contents; the mean concentration of mercury for (*Lethrinidae Lethrinus*) is 9.87ng/g in Portsudan city and 4.06ng/g in Suakin city but have the same value for *Serranus Subligarius*18.43 and 18.42ng/g in Portsudan and Suakin respectively. Generally this study explained that (*Serranus Subligarius)* has a tendency to accumulate mercury in its body particularly muscle tissues more than other specie (*Lethrinidae Lethrinus)*. This may be attributed to the fact that these two different species have different migratory and they hold different positions in the marine food.

Table 1 Concentration of mercury in two different species of fish samples of the Red Sea Sudanese coast (Portsudan and Suakin)

Sample number	Site	Fish species	Concentration, ng/g		Mean, ng/g	USFDA limits, ng/g
1	P	*LethrhrinidaeLethrinus*	1.59	mean	17.04	500
2	P	*LethrhrinidaeLethrinus*	4.10	9.87		
3	P	*LethrhrinidaeLethrinus*	23.93			
4	P	*SeiramusSubligarius*	14.00			
5	P	*SeiramusSubligarius*	35.76	18.43		
6	P	*SeiramusSubligarius*	5.54			
7	S	*LethrhrinidaeLethrinus*	4.13		10.69	
8	S	*LethrhrinidaeLethrinus*	3.83	4.06		
9	S	*LethrhrinidaeLethrinus*	4.22			
10	S	*SeiramusSubligarius*	16.29			

11	S	*SeiramusSubligarius*	32.08	18.42
12	S	*SeiramusSubligarius*	6.91	

*P stands for Portsudan city and S stands for Suakin city

The levels of mercury in the tested fish species are below published values for other fish species [26] and well below the acceptable limits for mercury in foods (as shown in Table 1) and thus unlikely to cause adverse effects to aquatic organisms. Our results may help to understand better the accumulation of the individual mercury in the selected tissues of the two fish species.

Acknowledgement

We wish to acknowledge Mr. Abu Baker M. Osman (Niala University) for his kind guidance through the literature of this work. Special thanks to lab staff of faculty of marine science and Faculty of Education, Red Sea University for help in sample collection.

References

[1] D. W. Boening, Chemosphere, 2010, 40, 1335.
[2] S. G. Downs, C. L. Macleod,J. N. Lester, Water Air Soil Pollut. 1988, 108, 149.
[3] L. Boszkel, J. Siepak, J. Falandysz, Poland. Pol. J. Environ. Stud., 2003, 12(3), 275.
[4] N. Rajesh, M. S. Hari, Spectrochim. Acta A., 2008, 70, 1104.
[5] D. Karunasagar, J. Arunachalam, S. angadharan, J. Anal. Atom. Spectrom., 1998, 13, 679.
[6] X. Zhu, S. D. Alexandratos, Microchem. J., 2007, 86. 37.
[7] N. L. D. Filho, D. R. Carmo do, Talanta, 2006, 68, 919.
[8] X. Li, Z. Wang, Anal. Chim. Acta., 2007, 588, 179.
[9] P. R. Devi, T. Gangaiah, G. R. K. Naidu, Anal. Chim.Acta, 1991, 249, 533.
[10] D. L. Tsalev, Acta B., 2000, 55, 917.
[11] E. T. Ritschorff, N. Fitzgerald, R. Mcluaughlin, I. D. Brindle,pectrochim.Acta B.,2005, 60, 139.
[12] M. Tuzen, M. Soylak, Bull. Environ. Contam.Toxicol., 2005, 74, 968.
[13] D. M. Cohen, How many recent Fishes are there? Proceeding California Academy of Science, 4th series, 1970, 38, 17.
[14] R. B. Clark, Marine pollution, 3rdedition, Clarendon Press Oxford, 1992, p98.
[15] A. Ruiter, Fish and fishery products composition, nutritive properties and stability. In Schmidtdorff, W.ed., United Kingdom: Biddles Limited. Fish meal and fish oil-not only by-products, 1995, p. 347.
[16] M. Bellanger, C. Pichery, D. Aerts, M. Berglund, A. Castaño, A., Cejchanová, M., et al. DEMO/COPHES, Economic benefits of methylmercury exposure control in Europe: monetary value of neurotoxicity prevention. Environ Health, 2013, 12(1), 3.
[17] N. A. Barak, C. F. Mason, The science of environment, 1990, 92.
[18] T. Agusa, T. Kunito, G. Yasunga, H.Iwata, A. Subramanian, A. Ismail, et al. Marine Pollu. Bull., 2005, 51, 896.
[19] F. H. Bashir, M. S. Othman, A. G. Mazlan, S. M. Rahim, K. D. Simon, Turk. J. Fish. Aquat.Sci., 2013, 13, 375.
[20] T. Agusa, T. Kunito, A. Sudaryanto, I. Monirith, S. K. Atireklap, H. Iwata, et al. 2007,145, 766.
[21] C. K. Yap, A. Ismail, S. G. Tan, Bull. Enviro. Conta. Tox., 2003, 71, 570.
[22] N. Pourreza, K. Ghanemi, Journal of Hazardous Materials, 2009, 161, 982.
[23] S. Janković, B. Antonijević, M. Ćurčić, T. Radičević,S. Stefanović, D. Nikolić, V. Ćupić, Tehnologija mesa, 2012, 53, 56.
[24] M. S. Adam, L. J. Emily, D. B. Gregory,S. R. S. R. John, Int. J. Environ. Res. Public Health.2014, 11, 6709.
[25] J. W. Moore, Inorganic Contaminant of Surface Water, Springer-Verlage, New York, 1991, p 117.

[26] WHO, Evolution of certain additives and contaminants Mercury Lead and Cadmium: In Sixteen Report of the Joint FAO/WHO Expert committee on food additives. WHO Technical Report Series, 1992, NO. 505.

Publication History

Received	18^{th} Sep 2014
Revised	20^{th} Feb 2015
Accepted	13^{th} Mar 2015
Online	30^{th} Mar 2015