International Journal of Ecology and Environmental Sciences 42 (4): 251-255, 2016
ISSN: 2320-5199 (Online)

Short Communication

Mercury Levels in Fish Marketed in the Metropolitan Region of Belém, Pará, Brazil

JULIANA DE SOUZA ARAUJO[1]*, MARCELO DE OLIVEIRA LIMA[2] AND TOMMASO GIARRIZZO[3]

[1] *Aquatic Ecology Group. Federal University of Pará. Av. Perimetral 2651, Terra Firme 66040170, Belém, PA – Brazil. E-mail: j.araujo.bio@gmail.com*
[2] *Evandro Chagas Institute. Environment Section. Rodovia B. R.-316, km 7, S/N, Levilândia 67030000, Ananindeua, PA – Brazil. E-mail: marcelolima@iec.pa.gov.br*
[3] *Aquatic Ecology Group. Federal University of Pará. Av. Perimetral 2651, Terra Firme 66040170, Belém, PA – Brazil. E-mail: tgiarrizzo@gmail.com*

ABSTRACT

Mercury is an environmental contaminant found in in aquatic ecosystems, derived from both manmade and natural sources. Studies of mercury contamination in fish have focused on areas with a known history of contamination, such as large rivers and their tributaries. As few data are available on the contamination of fish by heavy metals, the major urban centers in the Amazon basin have been surveyed, and in the present study, the mercury levels in the principal fish species marketed in some of the largest retailers in the city of Belém were evaluated. Samples were collected in March 2013 from the city's principal supermarkets and street markets, either in the form of whole fish or processed portions. A sample of 10-20 g of muscle tissue was taken from each specimen for preparation and analysis in a Cold Vapor Atomic Absorption Spectrometer. Only four of the 28 species analyzed presented mercury concentrations higher than those permitted by the World Health Organization (0.5 $\mu g.g^{-1}$). While contamination may be partly related to the feeding habits of the species, environmental variables are the principal determinants of contamination. Given this, there is a clear need for the monitoring of mercury contamination levels in fish supplies, and the careful evaluation of the supply chain, in order to minimize any major future risks to public health.

Key Words: Urban Center, Amazon, Contaminated Fish, Trace Element, Fairs and Supermarkets, Trophic Levels.

Níveis De Mercúrio Em Peixes Comercializados Na Reigão Metropolitana De Belém, Pará, Brasil

Resumo

O mercúrio é um contaminante ambiental presente nos ecossistemas aquáticos tanto por motivos antrópicos como por fatores naturais. Os estudos sobre contaminação por mercúrio em peixes foram direcionados a localidades onde há um histórico de contaminação, como grandes rios e seus afluentes. Tendo em vista que nenhum estudo sobre contaminação por metais pesados em peixes foi realizado nos grandes centros urbanos amazônicos, o presente trabalho teve como objetivo avaliar os níveis de mercúrio presente nas principais espécies de peixes comercializadas nos maiores pontos de venda do município de Belém. Amostragens foram realizadas durante o mês de Março de 2013 em alguns dos principais supermercados e mercados populares de Belém, adquirindo-se o pescado em postas ou inteiro. De cada indivíduo foi coletado 10 – 20 g de músculo, que foram preparados e analisados por meio de Espectrometria de Absorção Atômica com Vapor Frio. De todas as 28 espécies analisadas, apenas quatro apresentaram concentração de mercúrio superior à permitida pela Organização Mundial da Saúde que é de 5,0 $\mu g.g^{-1}$. Isto pode estar relacionado ao hábito alimentar das espécies, mas principalmente ao ambiente do qual elas procedem. Sendo assim, torna-se indispensável uma maior fiscalização quanto a procedência do pescado e seu monitoramento quanto aos níveis de contaminação por mercúrio, para assim prevenir qualquer dano futuro à saúde pública.

Palavras-chaves: Centro Urbano, Amazônia, Peixe Contaminado, Elemento Traço, Feiras e Supermercados, Níveis Tróficos.

INTRODUCTION

Mercury is an environmental contaminant that may be introduced into the aquatic ecosystem through both natural and anthropogenic processes (Fadini and Jardim 2001, Mieiro et al. 2012). Due to its high toxicity, especially in its methylated form, the potential effects of mercury contamination on the environment and through the continuous exposure of local organisms are attracting increasing interest from researchers around the world (Chan 2011, Rocha et al. 2012).

Until now, the principal reports of mercury contamination have come from regions with a long history of mineral extraction (Nevado et al. 2009), such as areas influenced by petrochemical plants and coal-burning industries, as well metal casting plants (Zhang and Wong 2007, Mieiro et al. 2011). In these areas, mercury enters the human body mainly through the ingestion of seafood and fish (Dorea 2003, Dorea et al. 2012).

In the specific case of the Amazon basin, despite many years of mining activity, more than 90% of the mercury found in the environment actually occurs naturally (Roulet et al. 2001, Beklger and Forsberg 2006). Mercury is present in the soil in association with iron, in ancient geological formations, and is leached into rivers during the rainy season (Comte et al. 2013). This process is accentuated by deforestation and burn-off for farming, which favors soil erosion, leading to the release of additional mercury into local tributaries (Comte et al. 2013, Kasper et al. 2014).

In the Amazon region, studies of mercury contamination in fish have focused on areas where contamination has occurred both naturally, and through human activities, and may be endangering the health of the riverside populations that often consume fish (Santos et al. 2000, Dorea 2003, Oliveira et al. 2010, Vieira et al. 2013). As no data are available on the contamination of the fish marketed in the largest urban centers in the Amazon region, the present study investigated the mercury concentrations in the principal fish species sold at some of the large retailers in the city of Belém, Brazil.

METHODS

The municipality of Belém is located in in the Brazilian state of Pará, in the north of country, and has 2,079,699 habitants. It is located on the right margin of Guajará Bay, formed by the confluence of the Guamá and Acara rivers near the Amazon Delta.

Collection and Preparation of Samples

Sampling was carried out in March 2013 in the principal supermarkets and street markets in the municipality of Belém, with specimens being obtained in the form of whole fish or steaks. The specimens were identified to the lowest taxonomic level, classified by feeding habits and trophic levels following Froese and Pauly (2016), and measured (total length, L_t) whenever possible. A 10-20 g sample of muscle tissue was extracted from the dorsal region of each specimen and stored in polyethylene bags. The samples were then washed with deionized water, shredded and homogenized with sterilized stainless steel surgical scissors, and transferred to glass tubes. These tubes were maintained at -4°C until analysis of the mercury content at the Evandro Chagas Institute in Belém.

Analyses of Mercury Content

An aliquot of approximately 500 mg of the homogenized material was weighed and transferred to glass volumetric flasks with 50 mL nitric acid, sulfuric acid, perchloric acid. Deionized water was then added to the flasks, which were transferred to a heating plate to be heated under reflux to a temperature of 250°C for 30 minutes. After digestion, the samples were cooled and hydrated to 50 ml with deionized water. After this acid digestion, the samples were analyzed by cold vapor atomic absorption spectrometry (CV-AAS) using a HG-201 Mercury Analyzer manufactured by SANSIO (Akagi et al. 1995).

RESULTS

We sampled 110 individuals belonging to 28 species and classified into five trophic categories (Table 1): planktivores (1 species), herbivores (1), detritivores (1), omnivores (1) and carnivores (24). The samples included 99 carnivorous fish, and 11 non-carnivores. Only four of the study species (*Plagioscion squamosissimus*, *Mugil* sp., *Carcharhinus* sp., and *Cichla monoculus*) presented a mean mercury concentrations above the value (0.5 μg g^{-1}) recommended by the World Health Organization, while some individuals of a fifth species, *Cynoscion microlepdotus*, also surpassed this threshold. *Carcharhinus* sp., and *Cichla monoculus* also presented contamination levels above the limit established by Brazilian legislation (ANVISA) for predatory fish - 1.0 μg g^{-1} (Figure 1).

Table 1. Feeding habits and trophic level of the species sampled in the municipal markets of Belém.

Species	Trophic category	Trophic level	N
Pomatomus saltatrix	Carnivore	4.5	1
Potamotrygon sp.	Carnivore	4	3
Gadus macrocephalus	Carnivore	4.01	2
Bagre bagre	Carnivore	4.01	4
Carcharhinus sp.	Carnivore	4.46	3
Lobotes surinamensis	Carnivore	4.16	3
Cynoscion microlepdotus	Carnivore	4.1	3
Prochilodus nigricans	Detritivore	2.38	5
Brachplatystoma flavicans	Carnivore	4.5	8
Brachplatystoma filamentosum	Carnivore	4.47	5
Airus parkeri	Carnivore	4.1	6
Lutijanus sp.	Carnivore	3.6	7
Selene brownii	Carnivore	3.72	3
Genyatremus luteus	Carnivore	3.5	1
Cynoscion acoupa	Carnivore	4.05	6
Plagioscion squamosissimus	Carnivore	4.4	5
Macrodon ancilodon	Carnivore	3.9	6
Brachplatystoma vaillantii	Carnivore	4.5	9
Megalopis atlanticus	Carnivore	3.61	1
Lutijanus sp.	Carnivore	3.6	2
Oncorhynchus keta	Carnivore	3.42	1
Pellona flavipinis	Carnivore	4.5	2
Sardinela brasiliensis	Planktivore	3.13	3
Scomberomorus crysorus	Carnivore	4.37	7
Mugil sp.	Omnivore	2.48	1
Colossoma macropomum	Herbivore	2.02	2
Hoplosternum litorale	Carnivore	2.86	3
Cichla monoculus	Carnivore	4.1	2

DISCUSSION

The results of the study show that most of the fish sold in the metropolitan area of Belém is within the tolerable limit of mercury contamination, and thus suitable for human consumption. While the feeding habits of the species contributed to these values, the environment in which the fish were caught appears to be the principal determinant (Dorea and Barbosa 2007, Kasper et al. 2009, 2012), given that the omnivorous *Mugil* sp. presented a higher level of contamination than expected for its trophic category. Species from areas with a known history of contamination tend to have higher concentrations of the metal, regardless of their trophic category, in comparison with more preserved areas (Kasper et al. 2009, 2012).

In addition, the simple presence of mercury in the environment does not guarantee contamination. A number of factors, such as pH, temperature, dissolved oxygen and the amount of nutrients in the water, as well as the bacterial flora that control the bioavailability of mercury, making it more or less susceptible to accumulation in the tissue of the organisms (Ullrich et al. 2001, Acha et al. 2011, Coelho-Souza et al. 2011). The species marketed in the metropolitan region of Belém had mercury levels similar to those found in the same study species in rivers with widespread contamination, such as the Madeira and Tapajós (Table 2).

While the mercury levels found in the present study were mostly relatively low, further studies are required to verify a wider range of species and different supply chains, as well as possible seasonal and ontogenetic variations in the level of mercury in the contaminated species. More effective controls on the origin of the fish sold in local markets, where data on the source of the fish is scarce or non-existent, are especially important. The risks and effects of mercury contamination on the population of Belém are still poorly-known, and there is a clear need for the monitoring of mercury levels in fish supplies from contaminated areas, in order to prevent potential future risks to public health.

ACKNOWLEDGEMENTS

We acknowledge the Group of Aquatic Ecology for their support in providing and processing of fish samples, and the Instituto Evandro Chagas for their support with laboratory chemical analysis. TG is the recipient of a CNPq productivity grant.

REFERENCES

Acha, D.; Hintelmann, H. and Yee, J. 2011. Importance of sulfate reducing bacteria in mercury methylation and demethylation in periphyton from Bolivian Amazon region. Chemosphere 82: 911-916.

Akagi, H.; Malm, O.; Kinjo, Y.; Harada, M.; Branches, F.J.P.; Pfeiffer, W.C. and Kato, H. 1995. Methylmercury pollution in the Amazon, Brazil. Science of the Total Environment 175: 85-95.

Belger, L. and Forsberg, B.R. 2006. Factors controlling Hg levels in two predatory fish species in the Negro river basin, Brazilian Amazon. Science of the Total Environment 367: 451-459.

Chan, L.H.M. 2011. From power to seafood safety: effects of global pollution on our children's health. Progress in Nutrition 13: 207-210.

Coelho-Souza, S.A.; Guimaraes, J.R.D.; Miranda, M.R.; Poirier, H.; Mauro, J.B.N.; Lucotte, M. and Mergler, D. 2011. Mercury

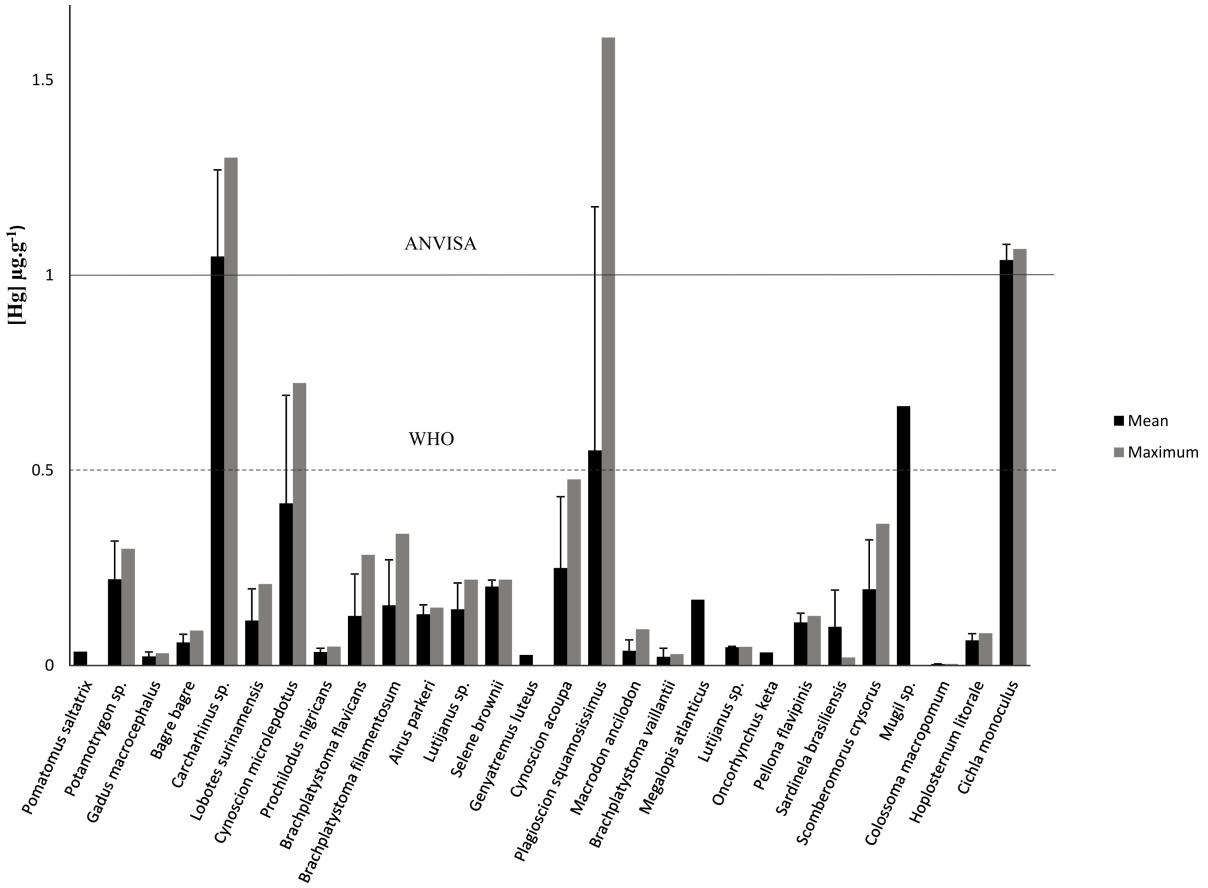

Figure 1. Mean, standard deviation and maximum mercury concentrations in 28 fish species analyzed in the municipality of Belém .

Table 2. Comparative mercury concentrations (µg g^{-1}) in fish from different regions of the Amazon basin.

Species	Mean	Locality	Reference	Mean value, present study
Cichla sp.	0.416	Madeira River	Dorea and Barbosa 2007	
	0.162	Negro River		
	0.47	Madeira River	Kehrig et al. 2008	
	0.38	Negro River		1.039
	0.55	Tapajós River		
	0.24	Balbina Reservoir		
	0.49	Tucuruí Reservoir		
Brachyplatistoma vaillanti	0.09	Madeira River	Basttos et al. 2008	0.022
Brachplatystoma flavicans	0.907	Madeira River	Basttos et al. 2008	0.127
Brachplatystoma filamentosum	1.359	Madeira River	Basttos et al. 2008	0.154
Pellona flavipinnis	1.597	Madeira River	Basttos et al. 2008	0.110
	0.327	Solimões River	Beltran-Pedreros et al. 2011	
Plagioscion squamosissimus	0.449	Madeira River	Basttos et al. 2008	0.551
	0.547	Solimões River	Beltran-Pedreros et al. 2011	
Prochilodus nigricans	0.342	Madeira River	Basttos et al. 2008	0.034
	0.056	Solimões River	Beltran-Pedreros et al. 2011	
Colossoma macropomum	0.126	Madeira River	Basttos et al. 2008	0.004
	0.063	Madeira River	Beltran-Pedreros et al. 2011	

and flooding cycles in the Tapajos river basin, Brazilian Amazon: The role of periphyton of a floating macrophyte (*Paspalum repens*). Science of the Total Environment 409: 2746-2753.

Comte, I., Lucotte, M., Davidson, R., Carvalho, C. J. R., Oliveira, F. A. and Rousseau, G. X. 2013. Impacts of land uses on mercury retention in long-time cultivated soils, Brazilian Amazon. Water Air Soil Pollution 224: 1515.

Dorea, J.G. 2003. Fish are central in the diet of Amazonian riparians: should we worry about their mercury concentrations? Environmental Research 92: 232-244.

Dorea, J.G. and Barbosa, A.C. 2007. Anthropogenic impact of mercury accumulation in fish from the Rio Madeira and Rio Negro rivers (Amazonia). Biological Trace Element Research 115: 243-254.

Dorea, J.G., Marques, R.C. and Isejima, C. 2012. Neurodevelopment of Amazonian infants: Antenatal and postnatal exposure to methyl- and ethylmercury. Journal of Biomedicine and Biotechnology 2012: Article ID 132876, 9 pages.

Fadini, P.S. and Jardim, W.F. 2001. Is the Negro River Basin (Amazon) impacted by naturally occurring mercury? Science of the Total Environment 275: 71-82.

Froese, R. and Pauly, D. (Editors). 2016. FishBase. Available in: http://www.fishbase.org. Accessed in January 2016.

Kasper, D.; Forsberg, B.R.; Amaral, J.H.F.; Leitão, O.R.P.; Pydaniel, S.S.; Bastos, W.R. and Malm, O. 2014. Reservoir stratification affects methylmercury levels in river water, plankton, and fish downstream from Balbina Hydroelectric Dam, Amazonas, Brazil. Environmental Science & Technology: 48 (2): 1032 – 1040.

Kasper, D.; Palermo, E.F.A.; Branco, C.W.C. and Malm, O. 2012. Evidence of elevated mercury levels in carnivorous and omnivorous fishes downstream from an Amazon reservoir. Hydrobiologia 694: 87-98.

Kasper, D.; Palermo, E.F.A.; Dias, A.C.M.I.; Ferreira, G.L.; Leitao, R.P.; Branco, C.W.C. and Malm, O. 2009. Mercury distribution in different tissues and trophic levels of fish from a tropical reservoir, Brazil. Neotropical Ichthyology 7: 751-758.

Mieiro, C.L.; Coelho, J.P.; Pacheco, M.; Duarte, A.C. and Pereira, M.E. 2012. Evaluation of species-specific dissimilarities in two marine fish species: mercury accumulation as a function of metal levels in consumed prey. Archives of Environmental Contamination and Toxicology 63: 125-136.

Mieiro, C.l.; Pacheco, M.; Duarte, A.C. and Pereira, M.E. 2011. Fish consumption and risk of contamination by mercury - Considerations on the definition of edible parts based on the case study of European sea bass. Marine Pollution Bulletin 62: 2850-2853.

Nevado, J.J.B.; Martin-Doimeadios, R.C.R. and Moreno, M.J. 2009. Mercury speciation in the Valdeazogues River-La Serena Reservoir system: Influence of Almadein (Spain) historic mining activities. Science of the Total Environment 407: 2372-2382.

Oliveira, R.C.; Dorea, J.G.; Bernardi, J.V.E.; Bastos, W.R.; Almeida, R. and Manzatto, A.G. 2010. Fish consumption by traditional subsistence villagers of the Rio Madeira (Amazon): Impact on hair mercury. Annals of Human Biology 37: 629-642.

Rocha, J.B.T.; Aschner, M.; Dorea, J.G.; Ceccatelli, S.; Farina, M. and Silveira, L.C.L. 2012. Mercury toxicity. Journal of Biomedicine and Biotechnology 2012: Article ID 831890, 2 pages.

Santos, E.C.D.; De Jesus, I.M.; Brabo, E.D.; Loureiro, E.C.B.; Mascarenhas, A.F.D.; Weirich, J.; Camara, V.D. and Cleary, D. 2000. Mercury exposures in riverside Amazon communities in Para, Brazil. Environmental Research 84: 100-107.

Ullrich, S.M.; Tanton, T.W. and Abdrashitova, S.A. 2001. Mercury in the aquatic environment: A review of factors affecting methylation. Critical Reviews in Environmental Science and Technology 31:241-293.

Vieira, S. M.; Almeida, R.; Holanda, I. B. B.; Mussy, M. H.; Galvao, R.C.F.; Crispin, P.T.B.; Dorea, J.G. and Bastos, W.R. 2013. Total and methyl-mercury in hair and milk of mothers living in the city of Porto Velho and in villages along the Rio Madeira, Amazon, Brazil. International Journal of Hygiene and Environmental Health 4: 1-7.

Zhang, L. and Wong, M.H. 2007. Environmental mercury contamination in China: Sources and impacts. Environment International 33: 108-121.

Received 25August 2016
Accepted 28 October 2016