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Evaluation of total mercury concentrations in fish consumed in the municipality of Itaituba, Tapajós River Basin, Pará, Brazil

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Abstract

The environmental exposure to mercury by riverine and Indian communities can occur through the ingestion of fish and products contaminated by mercury compounds. The present study aims to evaluate the total mercury concentration in the different fish species most consumed in the municipality of Itaituba, Tapajós river basin, where there are intense gold-mining activities. These fish samples were analyzed by atomic absorption spectrophotometry by cold vapor technique, Automatic Mercury Analyzer HG-3500. The largest mercury concentrations were found in the carnivorous species ranging from 112.4 to 2250 $\mu\text{g/g}$, while the detritivorous, herbivorous and omnivorous species presented total mercury levels ranging from 3.2 to 309.8 $\mu\text{g/g}$, which is below the limit established by the World Health Organization. This paper also reports and identifies which species are more polluted and present a statistical relationship among concentration and weight of the carnivorous species studied in detail, *Brachyplatystoma flavicans* (dourada) ($r^2 = 0.691$) and *Pseudoplatystoma* sp. (surubim) ($r^2 = 0.654$). © 2000 Elsevier Science B.V. All rights reserved.

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1. Introduction

The Amazon region is very well known for intense gold exploration. The gold-mining areas extend for more than 170 000 km², and approximately 60% of this area is located in the state of Pará (Leal et al., 1994). In recent decades, the gold-mining activities have been responsible for environmental damage due to the indiscriminate release of mercury into rivers, soils and atmosphere.

When the residues of the gold extraction process reach the rivers, they carry large quantities of mercury. Bacteria then convert this metal into methylmercury, the most toxic mercury compound in the environment (Jernelöv, 1973). It is then bioaccumulated in fish and biomagnified through the aquatic food chain.

Since more than 90% of methylmercury is in aquatic biota (benthic microorganisms and fish) (Mitra, 1986; Lacerda et al., 1994), the major source of human exposure to methylmercury is the consumption of fish (Dorea et al., 1998; Kehrig et al., 1998; WHO, 1990).

For this reason the evaluation of the levels of mercury in the fish represents an important factor not only from the toxicological point of view, but also for evaluating potential impacts on public health.

Among the gold-mining areas, the Tapajós river basin is one of great importance, because it contributes half the gold produced by gold-mining areas in Brazil (Rodrigues et al., 1994). This basin, therefore, is suffering the largest impacts of the gold-mining activities.

This article shows recent measurements of concentration of total mercury in different species of fish, consumed in the municipal district of Itaituba. These fish are coming from Itaituba as well from other places such as municipal district of Aveiro in the state of Pará. This study identifies which are the most contaminated of these species and it presents a statistical relationship between concentration and the weight of the fish.

2. Area of study

The municipal district of Itaituba is located in

the southwest of the state of Pará and has an area of 62 565 km². The climate in the area is hot and humid. Approximately 95% of its area is along the Tapajós river, whereas the remaining 5% belongs to the Amapá river basin (Leal et al., 1994).

The population of the municipality of Itaituba is approximately 97 630 inhabitants (IBGE, 1996) with diversified alimentary habits (Malm et al., 1995).

The economic structure of this municipality is formed around mineral productions, vegetable farming and fishing, but mainly on mineral extraction of gold, cassiterite and tantalite. The tourist potential of this area has been concentrated on the Tapajós river.

This municipal district doesn't have a fishing colony, so it has a poor infrastructure, resulting in insignificant yields. All the fishing activities are done in a rudimentary way, and the whole fish production is consumed in the municipal district. Among the species that contribute the largest portions of the fishing production are *Leporinus* sp. (aracu) and *Plagisocion squamosissimus* (pescada branca) (IDESP, 1977).

3. Materials and methods

Fish were collected in April and June in 1998, by the Evandro Chagas Institute, in Itaituba municipality. The samples were bought at the municipal market of Itaituba. The identification of the fishes' origin (the place where they were fished) was investigated with the collaboration of a fisherman. A previous study had been performed to determine which were the most consumed fish species by the local community of Itaituba. The sampling concentrated on carnivorous, omnivorous, detritivorous and herbivorous species. All the information about each sample was obtained through a control chart of fishes.

Recent studies in Tapajós river basin demonstrated a larger accumulation of mercury in carnivorous species than in non-carnivorous species (Malm et al., 1995). In this work, six carnivorous species were studied in detail: the Pimelodidae family (*Brachyplatystoma filamentosum*, filhote), (*Brachyplatystoma flavicans*, dourada) and (*Pseu-*

doplatystoma sp., surubim); the Sciaenidae family (*Plagisocion squamosissimus*, pescada branca); the Cichlidae family (*Cichla* sp., tucunaré); and the Clupeidae family (*Pellona* sp., sarda). Nearly 57% of the fish studied here are of this alimentary habit.

In total, 105 fish of 10 species were collected in the following localities: São Luís do Tapajós, Itapacurazinho river, Cipotuba, Cupari river, Itaituba city, Pecuaçu, Brasília Legal and Boca da Onça.

The total mercury analysis was carried out at the laboratory of Human Ecology and Environment — COEHMA, Evandro Chagas Institute, by atomic absorption spectrophotometry by cold vapor technique, Automatic Mercury Analyzer HG-3500 (Akagi et al., 1995). Reproducibility and accuracy were determined by means of the triplicate analyses and analyses of certified reference standard (DORM-2). The detection limit of methodology used was determined according to Akagi et al. (1995) as 0.5 µg/g mercury.

The results of the determinations of mercury concentrations were evaluated through statistical treatments using a Minitab 10.1 program (Chatterjee and Price, 1977). In this study, it was possible to evaluate the variables: mercury concentration (µg/g) and weight of fish (g).

4. Results

The map in Fig. 1 shows the sampling sites of the most consumed fish specimens by the riverine population. In this study, it was observed that approximately 35% of the total analyzed samples presented mercury levels above the maximum concentration permissible for human consumption, 500 µg/g (WHO, 1972). This can be attributed, to the intensive activities of gold-mining.

The mean mercury concentrations and mean weight of the studied fish species, are show in Fig. 2. The major content of mercury was observed in carnivorous species. The surubim and dourada species were found to have the largest concentrations and weights. In others species, it was not possible correlate concentration of mercury with weight. Fish of the same species collected in the

same location and time indicated a natural variability in mercury concentrations. This can be explained by the great diversity of fish in the Amazon region.

The values of mercury concentration in fish analyzed samples are shown in the Table 1. The largest mercury concentrations were found in carnivorous species. These species of fish presented mean levels of mercury of 634.2 µg/g, with a minimum value of 112.4 µg/g and a maximum of 2250 µg/g. Only the carnivorous species had mean mercury values above permissible limits for human consumption.

Mercury concentration in detritivorous, omnivorous and herbivorous species ranged from 3.2 µg/g to 309.8 µg/g. Of these measurements, the levels of mercury in *Mylossoma* sp. (pacu) and *Colossoma macropomum* (tambaqui), important in local fishing activity were found to range from 3.2 to 150.7 µg/g. These concentrations are well below of permissible limit to human consumption of 500 µg/g (WHO, 1972).

Among the carnivorous species studied, pescada, surubim, tucunaré and dourada presented values above of maximum limit for human consumption, 500 µg/g (WHO, 1972). High mercury levels also were found in Itaituba and Jacareacanga municipalities from 1987 to 1989 in pescada (130–1140 µg/g) and surubim (720–2580 µg/g) species and in 1991 were found in pescada (402–1231 µg/g) and tucunaré (185–666 µg/g) (Rodrigues et al., 1994).

The statistical treatment involved calculation of the coefficient of regression, between mercury content and weight for species: *Pseudoplatystoma* sp. (surubim) (Fig. 3) ($r^2 = 0.654$) and *Brachyplatystoma flavicans* (dourada) (Fig. 4) ($r^2 = 0.691$).

5. Discussion

The high variability of mercury values observed in carnivorous fish makes it difficult to generate advice on fish ingestion to the local population (Malm, 1998).

According to the high levels of mercury in fish observed in this study (35% of total samples pre-



Fig. 1. Location of sampling sites along the Tapajós river basin of Aveiro and Itaituba municipality, Pará State, Amazon.

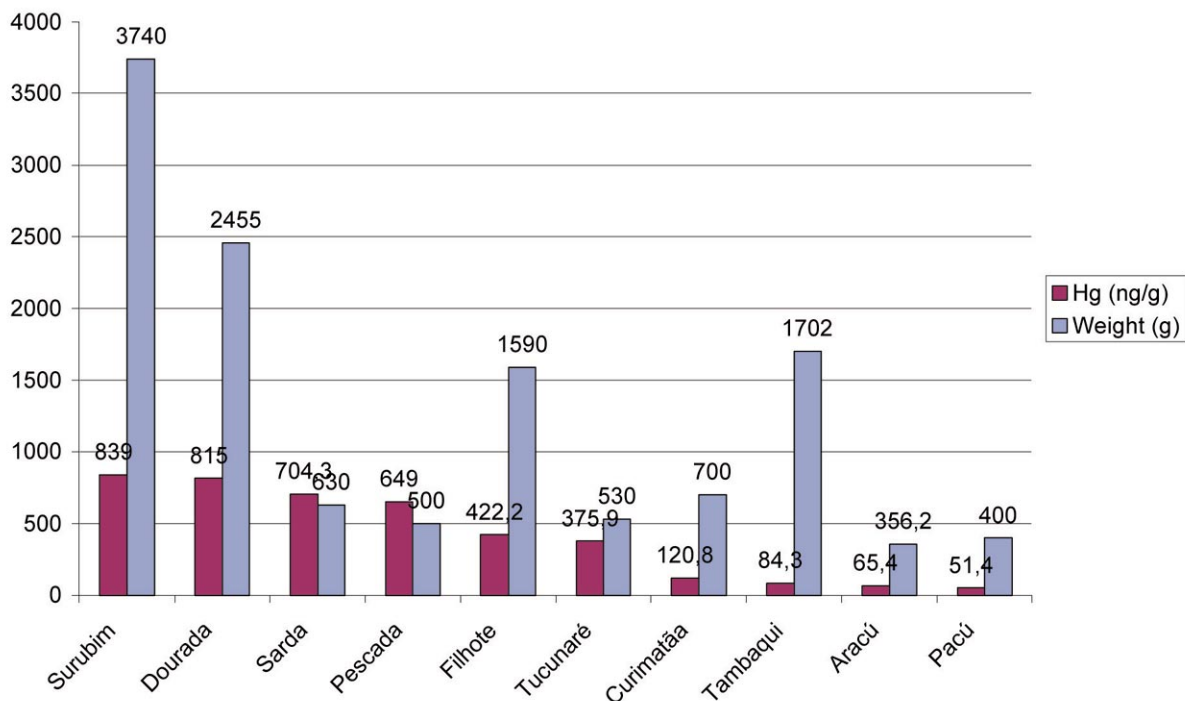


Fig. 2. Summary of the mean distribution of the total mercury concentration and mean weight of the studied species.

sented values above $500 \mu\text{g/g}$), a methylation is occurring in this area, as 85% of total mercury is in the form of methylmercury (Mitra, 1986). This affects the riverine population who are great con-

sumers of fish, and represent the main group at risk.

Although fish are considered to be the main source of methylmercury exposure, nowadays they

Table 1

Mercury concentrations in muscle tissue (wet wt.) of fish of Itaituba municipality, Tapajós river basin, Amazon

Species	Alimentary habit	n^a	Hg (ppb)	
			Interval	Average \pm S.D.
<i>Brachyplatystoma flavicans</i> (dourada)	Carnivorous	10	212.0–1356.0	815.0 ± 372.0
<i>Brachyplatystoma filamentosum</i> (filhote)	Carnivorous	10	112.4–891.8	422.2 ± 218.2
<i>Pseudoplatystoma</i> sp. (surubim)	Carnivorous	10	215.0–1757.0	839.0 ± 511.0
<i>Plagioscion squamosissimus</i> (pescada branca)	Carnivorous	11	331.0–2250.0	649.0 ± 549.0
<i>Cichla</i> sp. (tucunaré)	Carnivorous	10	214.4–610.5	375.9 ± 155.3
<i>Pelona</i> sp. (sarda)	Carnivorous	10	476.7–1226.1	704.3 ± 275.6
<i>Leporinus</i> sp. (aracú)	Herbivorous	13	27.0–126.0	65.4 ± 26.7
<i>Prochilodus nigricans</i> (curimatã)	Detritivorous	11	45.7–309.8	120.8 ± 76.8
<i>Mylossoma</i> sp. (pacú)	Herbivorous	10	3.2–125.3	51.4 ± 49.1
<i>Colossoma macropomum</i> (tambaqui)	Herbivorous	10	51.8–150.7	84.3 ± 32.1

^a Number of fish analyzed.

Pseudoplatystoma sp.

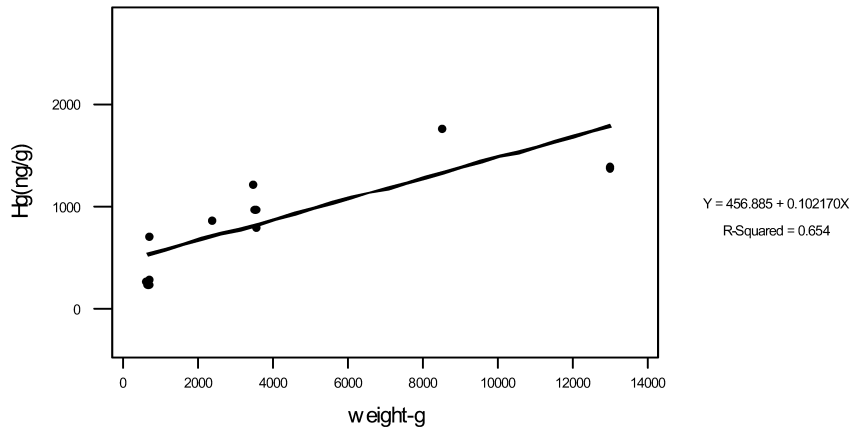


Fig. 3. Mercury concentration ($\mu\text{g/g}$) vs. fish weight of *Pseudoplatystoma* sp. (surubim) from the Itaituba municipality.

are within the consumption diary of many populations. Besides that, the consumption of fish has been also found to reduce the risk of coronary heart disease (Egeland and Middaugh 1997). For these reasons, a fish is a great source of protein and possesses low levels of saturated fat (Egeland and Middaugh 1997). Fish can't be banned in the diets of riverine and Indian communities.

Our results show a positive correlation between mercury concentration and weight of fish for surubim (*Pseudoplatystoma* sp.; Fig. 3), and possibly negative correlation between mercury concentration and body weight for dourada (*Brachyplatystoma flavicans*; Fig. 4) in the region. While a definitive explanation for this fact would still be premature, it is conceivable that, given that the

Brachyplatystoma flavicans

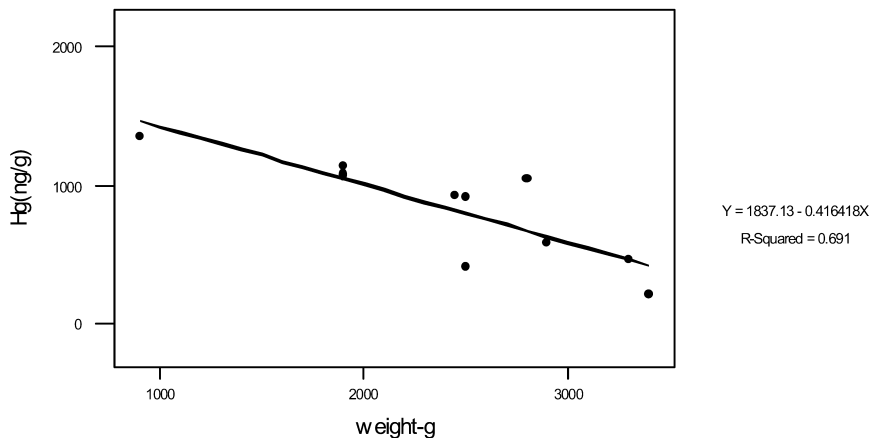


Fig. 4. Mercury concentration ($\mu\text{g/g}$) vs. fish weight of *Brachyplatystoma flavicans* (dourada) from the Itaituba municipality.

specie in questions is known for migrating across very long distances (Bartem and Goulding, 1997), the sampled specimens might come from different populations in transit through the area. In this case, the larger specimens could have previously fed upon non-contaminated prey caught elsewhere.

In the Amazon, an area of tropical climate, the relationship between mercury concentration and fish weight (Fig. 4), for some fish species, is not always observed. This may be associated with the species biodiversity found in region, and also the diet and capacity to migrate of the species, as well as others parameters of the aquatic environment, such as flow dynamic, Hg content in sediments, organic matter, among others (Reuther, 1994).

6. Conclusions

For the results present in this work (1998) and studies performed previously (1987, 1989, 1991), it was observed that pescada branca, tucunaré and dourada, still contain high levels of mercury. These results are troubling because the methylmercury is bioconcentrated in fish, creating a risk to the populations that live in this area and that eat the contaminated fish.

Although data for total mercury levels in fish in polluted Brazilian locations are available (Fernandes et al., 1990), there is very little published information yet about living conditions of people in these areas and also the environmental conditions of Brazil's basin.

In gold-mining areas, nowadays, the burning of amalgam is done in open air, with disastrous consequences for the whole region. The harmful effects to humans and the environment are well known. However, there is no official control of the gold production and use of mercury in gold-mining. Generally the gold-miners are poor people, with little education, who work with mercury in an indiscriminate way without understanding of the dangers to which they are exposed.

Riverine communities suffer the impacts of indiscriminate release of mercury to the environment. Therefore education is very important for a solution to the problem of mercury emission. New

actions need to be taken quickly to evaluate the potential future epidemic situation, and to avoid turning areas of great gold-mining, such as the Itaituba municipality, into an enormous environmental tragedy.

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