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Mercury Levels in Muscle of Some Fish Species from the Dique Channel, Colombia

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Gold mining is an activity that has been increasing during the last ten years in Colombia. Most mining activities are carried out using mercury for gold amalgamation. In a recent publication we stated that in the Sur de Bolivar, the main gold mining zone in Colombia, the highest mercury concentration in hair was observed in fishermen (Olivero et al. 1995). The Magdalena River, the largest and most important river in Colombia, receives all this contamination and carries it to the Atlantic Ocean through two means: The main river course and the Dique Channel. The Dique Channel is surrounded by many marshes, which are a major source of fish for nearly two hundred thousands people in northwestern Colombia.

The goal of the present study was to determine, for the first time, the content of mercury in muscle tissue of the four most popular fish species purchased in some towns along the Dique Channel, to establish whether these concentrations fall within the WHO guidelines, and to identify those species which can be consumed with less risk.

MATERIALS AND METHODS

The Dique Channel is a freshwater ecosystem which is located in northwestern Colombia (lO°OO'-lO°23'N and 74°27'-75°19'W). It has a total length of 114.5 km, minimal depth of 2.5 m, average water flow rate of 115 m^3/sec, and a calculated sediment discharge of 822 m^3/d. It is located approximately three hundred kilometers from the gold mining zone in Colombia, and connects the Magdalena River to Cartagena Bay. From June 1995 to February 1998, four fish species were purchased from local fishermen in three fishing towns along the Dique Channel: Soplaviento, Gambote, and Maria la Baja (Fig. 1). The fish were selected from different trophic levels including detritivorus with tendency to zooplanktonic Triportheus magdalenae (Arenca); hervibores, Prochilodus reticulatus magdalenae (Bocachico), and the carnivores Rhamdia sebae (Barbudo) and Pseudoplatystoma fasciatum (Bagre pintado).

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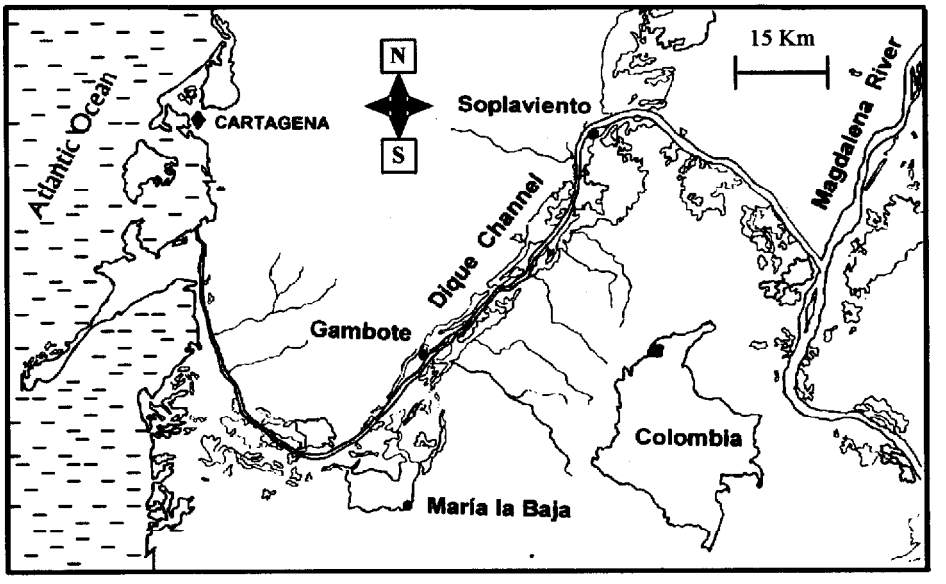

Figure 1. Map of the Dique Channel illustrating the sites from which fish samples were obtained.

Fish samples were placed in polythene bags and stored frozen before analysis. A portion of the dorsal muscle tissue was dissected from each fish with teflon knifes for the determination of mercury. Before extraction of muscle tissue from each fish, length was determined.

Total mercury concentrations in fish muscle were determined by cold vapor atomic absorption spectroscopy. Muscle samples were acid-digested (mixture H_2SO_4-HNO_3 2:1 v/v) at 100-110°C, for 3 hr (Sadiq et al. 1991). Three replicate determinations were made for each sample, the detection limit being (S/N=3) 7.4 µg/Kg for one g sample. For quality assurance, standard reference material and fish muscle spiked with known amounts of mercury were analyzed. Analytical recovery of Hg in spiked samples averaged 98.5±14% (n=6). The analysis of the certified material (Tort-1, National Research Council Canada) provided a mean value of 280±20 µg/Kg, being the certified value 330±µg/Kg. The mean coefficient of variation of Hg concentrations calculated from triplicate analysis of individually digested subsamples was 12.3% (except for those found within the detection limit).

Data in every mercury analysis were reported as three subsample means (for each fish), with their respective standard deviations. The evaluations of the different mean mercury concentrations among species were performed by Analysis of Variance. Where differences were significant, Newman Keul's Test (Tallarida and Murray 1986) was used

as a post test. Simple linear regression analysis (Walpole and Myers 1991) was performed to evaluate correlations between mercury content and fish length. Significance levels were set at $p \leq 0.05$.

To avoid missing data during statistical procedures, when the concentration of total mercury in a sample was lower than the detection limit, a mean value equal to half of the limit value was used.

RESULTS AND DISCUSSION

The results of mercury analysis in available fish of some communities along Dique Channel between June 1995 and February 1996 are shown in Table 1. The mean concentrations increased in the following order: Prochilodus reticulatus magdalenae (Bocachico) < Rhamdia sebae (Barbudo) < Pseudoplatystoma fasciatum (Bagre pintado) < Triportheus magdalenae (Arenca).

Table 1. Total mercury concentration (µg/Kg) wet weight) in muscle of fishes collected in the Dique Channel.

Species	Total Mercury (µg/Kg Wet Weight)			
	Soplaviento	Gambote	María la Baja	Total Values
Triportheus magdalenae	48±10†	73±39	150±36	105±56
	26-59‡	34-139	82-219	26-219
	n=8	n=10	n=17	n=35
Prochilodus reticulatus magdalenae	DL	12±9	DL	10±8
	DL-9	DL-29	DL-13	DL-29
	n=6	n=19	n=6	n=31
Rhamdia sebae	24±7	17±5	70±23	40±29
	15-33	9-24	34-102	9-102
	n=6	n=9	n=10	n=25
Pseudoplatystoma fasciatum	55±22	63±34	61±41	60±32
	37-94	29-125	17-129	17-129
	n=6	n=10	n=6	n=22

†. Mean±standard deviation, ‡. Range, n. Number of samples.
DL. Detection limit (7.4 µg/Kg).

In all samples, the concentrations varied between non detectable (ND) and 219 µg/Kg; the detection limit being 7.4 µg/Kg for a S/N=3.

The highest values found in fish from the Dique Channel were lower than those found in fish species from The Lower Gállego and Cinca Rivers in

Spain (Raldua and Pedrocchi 1996) Barbus graellsi, Cyprinus carpio and Exos lucius, being bottom-feeding, omnivore and a tertiary consumer, respectively. In the Tapajos River (Malm et al. 1995), an Amazon water body highly exploited by gold mining activities, the average value for mercury in muscle of carnivorous fish was 690 µg/Kg, almost ten times higher than those found in the Dique Channel. On the other hand, Falter and Scholer (1994) reported that total mercury in fish muscle from the Neckar River varied between 16 to 812 µg/Kg, with the highest value found in the barble, a consumer fish.

In the Dique Channel, the concentrations of mercury in the detritus-zooplankton eating species arenca were higher than those found in the fish-feeding species barbudo and bagre pintado, which indicates that a bioaccumulation process may be associated. The presence of mercury in arenca is probably due to the transport of this metal with sediments, where this species feeds.

In agreement with the analysis of variance at the 5% significance level, there were significant differences among means of mercury in muscle in different species analyzed. Table 2 shows the results for the Newman Keul's Test performed to verify the differences between the means of mercury concentrations for the different species. It can be stated that at the $p<0.01$ level, there were significant differences among their mean concentrations.

Table 2. Results of the Newman Keul's Test for mercury content between different species.

Population Pair	Difference µg/Kg	SE	q	$q_{0.95}$	$q_{0.99}$
PR : TM	95	6.5	14.64	3.70	4.52
PR : PF	50	7.3	6.85	3.37	4.21
PR : RS	29	7.0	4.19	2.80	3.71
TM : RS	65	6.9	9.49	3.37	4.21
TM : PF	45	7.1	6.26	2.80	3.71
RS : PF	20	7.7	2.68	2.80	3.71

PR: Prochilodus reticulatus maqdalenae TM: Triportheus magdalenae
RS: Rhamdia sebae PF: Pseudoplatystoma fasciatum
SE: Standard error q: Studentized range.

Based on analysis of variance, total mercury concentrations in muscle of arenca and barbudo obtained in Maria la Baja were significantly different ($p<0.01$) than those caught at other stations. In fact, the fish obtained at this

station came from marshes where the Dique Channel has more influence. This means that its waters flow into this water-body, increasing the sediment deposition. On the other hand, fish coming from Soplaviento and Gambote are caught in marshes that receives less influence from the Dique Channel.

The correlation analysis showed a significant negative correlation between mercury in muscle and fish length for barbudo ($R=-0.401$, $p=0.047$, $n=25$). Although the cause of this phenomenon has not been investigated yet, it is possible to infer that this species may be more susceptible to its environment, thus experiencing better growing conditions in those places where low contamination exists, as opposed to those places where contamination is relatively higher and their physiology can be affected. Significant correlations ($p<0.85$) between mercury in muscle and fish length for the remaining species were not obtained. Similar results were also reported by Jackson (1991).

Mercury concentrations in aquatic species > 75 µg/Kg should be attributed to water pollution due to human activities (Hakanson 1984). In this study, arenca seems to be the species which may be accumulating mercury in this ecosystem, however the highest mercury concentrations did not reach the limits levels internationally accepted for considering a fish not acceptable for human consumption (WHO 1990). On the other hand, bocachico, the most popular species among river communities and all over the Atlantic Colombian coast, presents low levels that make this species the best for consumption.

Considering the mean arenca's weight is 94.5±22.7 g (n=28) and the mean mercury concentration found in this fish species in Maria la Baja (150±36 µg/Kg), a daily intake of three fish represents a total ingestion of 297.7 µg/week, just 2.3 µg less than the provisional tolerable weekly intake (PTWI) value of 300 µg of total mercury per person (Galal 1993). This fact establishes a real problem for those people whose diet is based on arenca as a protein source. Because of the small size of arenca, it is common for fishermen's families from Maria la Baja to eat more than three arencas per day, which evidently is a health risk for this community.

Finally, it is important to establish how the habitat preference affects the intake and the development of barbudo and how the mercury bioaccumulation process is accomplished in arenca. Currently, a research program to measure the concentration of mercury in the hair of fishermen is being conducted. In addition to this, permanent mercury monitoring in the species used in this study is fundamental to guarantee the quality of life of those people whose diet is based on fish food.

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