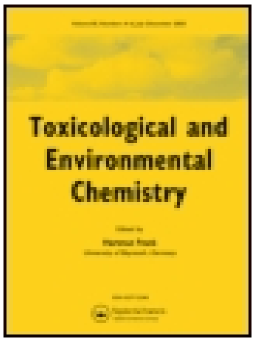

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Short communication

Total and methyl mercury in small marine biota caught off the coast of Chennai, India

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Total and methyl mercury in small marine biota caught off the coast of Chennai, India

Abstract

This study reports the concentrations of total mercury and methyl mercury in sixteen families of marine biota caught off the coast of Kasimedu in Chennai, India, an important but understudied fish landing region. These included the commonly caught croakers, carangids, rays, goat fish, anchovies, crabs, and prawns. There was no correlation between total mercury or methyl mercury with fish length or mass. All concentrations were lower than the Food Safety and Standards Authority of India limits (total mercury = 500 μg/kg; methyl mercury = 250 μg/kg). Some values were above screening levels (total mercury > 40 μg/kg wet weight) when considering possible adverse effects in predatory fish that consume the analyzed biota.

Key words. Fish, Mercury, Chennai, Kasimedu, Bioaccumulation.

1. Introduction

Mercury is a global toxic pollutant. It is emitted from anthropogenic and natural sources, and cycles reversibly between air, water (ponds, lakes, rivers, oceans), soil and vegetation. The highly toxic methyl mercury (MeHg) is bioaccumulated and biomagnified in aquatic food chains, to the extent that concentrations in top predators can be a million times higher than in water. Consumption of aquatic biota is a major route of MeHg exposure in humans globally (Selin 2009).

The Global Minamata Convention of Mercury (UNEP 2019a) has been adopted to safeguard humans and environment from harmful effects of mercury exposure. This necessitates the observations of mercury in aquatic biota as they are directly linked to human health. Mercury levels in biota have been suggested to be considered when evaluating the effectiveness of the Minamata Convention on Mercury (UNEP 2019b).

India is becoming a major producer of marine fish~~eries~~. In the year 2014, it was seventh in total marine capture production in the world (FAO 2016). The average consumption of fish in India is also increasing from 0.7 kg/capita/y in 1961 to 3.5 kg/capita/y in 2013 (Barik 2017). As such, determination of mercury contents of marine fish is important to understand what might be the exposure to mercury for people who consume those fish. Moreover, concentration of mercury in fish is controlled by direct and indirect drivers of anthropogenic changes. While fish mercury levels will directly respond to direct mercury emissions, ecosystem changes such as temperature increase and food-web shifts have been shown to be very important in influencing the future concentrations of mercury in marine biota (Schartup et al. 2019; Schartup et al. 2018). Therefore, it is important to establish baseline levels of mercury in biota at present, so that future observations can be better explained in terms of increased or decreased anthropogenic mercury pollution or changes in climate or ecosystem.

This is a huge task in India, as it has a vast coastline. However, given the importance of India in the national and international seafood market, a database of mercury in marine biota has to be developed. The objective of this work was to analyze MeHg and THg content in sixteen families of fish caught off the coast of Kasimedu landing center in Chennai, India, and to place them in comparison with respect to the global fish mercury observations and consumption guidelines reported in the literature (Evers et al. 2018; Evers and Sunderland 2019).

2. Materials and Methods

2.1. Sampling site and sample collection

Fish samples were collected from local anglers near the Kasimedu fish port (13°7′43″N, 80°17′59″E) in Chennai, on the coast of Bay of Bengal, during March – September 2018. Tamil Nadu ranked second in marine landings in India in 2016 (CMFRI 2017). Kasimedu is a major fish landing center in the state of Tamil Nadu capturing 200 tonnes of fisheries per day (Musthafa, Arunachalam, and Raiyaan 2019). The rivers Cooum and Adyar flow into the sea at about 10 km and 15 km, respectively, to the south of the port, and river Koutalaiyar about 15 km north of the port at Ennore creek (Mohanraj et al. 2012). Ennore creek also drains effluent from petroleum, fertilizer and coal-fired power production industries (Musthafa, Arunachalam, and Raiyaan 2019). The local anglers use mechanized fishing boats and generally use gill nets of size (no.10) 52 mm to catch fish, and venture up 80 km from the seashore for seafood collection. They catch fish for their own consumption and for sale in the local market. Some catch is sold to nearby cities. The samples for this study were caught with the help of these anglers. Caught individuals were shipped as whole in iceboxes overnight and stored at -20 °C until analysis.

2.2. Laboratory analysis

Previously published procedures were followed (Subhavana, Keerthana, and Qureshi 2020). Total length and mass of samples were determined. Fish samples were thawed and muscle fillet were weighed and oven-dried at 60 °C to constant weight (Schmidt et al. 2013) (results were similar to freeze-dried samples, n = 12) . Moisture content was determined and dried samples were homogenized using a porcelain mortar and pestle.

THg was determined by analyzing the dry homogenized sample directly in a direct mercury analyzer, DMA-80 (Milestone Srl. Via Fatebenefratelli, 1/5 - 24010 Sorisole, BG, Italy) (Djermanovic, Baralic, and Pejic 2020; Subhavana et al. 2019). MeHg was analyzed after toluene extraction and L-cysteine back extraction of MeHg (Calderón et al. 2013; Maggi et al. 2009). QA/QC was maintained by method blanks (0.093 ± 0.020 ng, n = 14) and recoveries against reference materials (IAEA-407, recoveries within the reported range 188–212 µg/kg, n = 3) and repeated measurements of tuna fish homogenate [r.s.d = 6.3 %, mean = 157.9 µg/kg wet weight (ww), n = 7] for MeHg, and (IAEA-336, recoveries within the reported range 160–240 µg/kg, n = 6) for THg.

3. Results and discussions

Sixty-one individuals from sixteen families were collected (Table 1). These included common commercially exploited fish families in India (MPEDA 2020) such as anchovies, mackerel, crab, scad, rays, sardine, pony fish, anchovies, goat fish and prawns, and most of the major families caught at Kasimedu by fish trawl in the period 1998-2007 (threadfin breams, rays

& skates, silverbellies, ribbon fish, carangids, goat fish, lizard fish, croakers, clupeids, shrimps, crabs and cephalopods, more than 3% contribution to total landings) (Mohanraj et al. 2012). Length and weight characteristics, moisture contents, and the THg and MeHg concentrations of analyzed biota are presented in Table 1. MeHg concentrations were 16.7±12.1 µg/kg ww (min, max = 3.2, 72.3 µg/kg ww; 5th, 95th percentile = 4.1, 41.3 µg/kg ww), and THg concentrations were 22.1±15.6 µg/kg ww (min, max = 4.2, 98.0 µg/kg ww; 5th, 95th percentile = 5.9, 50.8 µg/kg ww).

There was no statistically significant difference between THg or MeHg concentrations in sampled pelagic, demersal or shell fishes (one-way ANOVA). Croakers (average 32.1 µg/kg ww, range 16.9–72.3 µg/kg ww), mackerel (average 37.5 µg/kg ww, range 33.0–41.8 µg/kg ww), goat fish (average 20.8 µg/kg ww, range 5.9–41.3 µg/kg ww) and prawns (average 19.3 µg/kg ww, range 3.6–52.5 µg/kg ww) had somewhat higher MeHg concentrations [Table 1 near here].

The Food Safety and Standards Authority of India limits fish THg to 500 µg/kg and MeHg 250 µg/kg, respectively (FSSAI 2017), assumed to be on wet weight/fresh weight basis (Subhavana, Keerthana, and Qureshi 2020). The Japanese limit is 400 µg/kg ww of THg (Storelli et al. 2005). Samples analyzed in this work did not have THg or MeHg above these limits. The general guidelines (Evers et al. 2018) on consumption of fish stipulate that consumption of fish with THg concentrations above 50 µg/kg ww and below 220 µg/kg ww may be limited to 1 to 2 meals per week, and fish with THg below 50 µg/kg ww may be consumed unrestricted. Based on the obtained results, the analyzed species in this work may be consumed for more than 2 meals per week. However, it has also been shown (Subhavana, Keerthana, and Qureshi 2020) that even if fish THg concentrations are below 105 µg/kg ww, there was a 14% probability that subsistence fishermen in Nellore, India, could have mercury intake above than the USEPA reference dose for mercury (Rice, Schoeny, and Mahaffey 2003), 0.1 µg/kg-BW/d (micrograms of mercury per kg body weight per day). So very high consumption rates may still lead to exceedance of reference dose [roughly equal to twelve 200 g meals per week for a 65 kg adult consuming marine biota with the study median THg concentration of 19.7 µg/kg ww; which is plausible for some subsistence fishermen (Subhavana, Keerthana, and Qureshi 2020)].

When comparing the obtained results with the reports on Global Biotic Mercury Synthesis and Mercury Monitoring in Biota (Evers et al. 2018; Evers and Sunderland 2019), for human health, the obtained concentrations are less than a THg concentration of 220 µg/kg ww and lie in the 'lower concern' range. Screening benchmarks for effects on reproductive success on predatory fish may be crossed if these predators consume prey fish with THg greater than 40 µg/kg ww (Depew et al. 2012; Evers and Sunderland 2019). Seven out of the sixty-one analyzed species had THg higher than 40 µg/kg ww.

Overall, while currently the obtained concentrations may overall appear to be of lower concern, it is noted that THg and MeHg in fish species also depend on mercury availability at the base of the food-web (water, plankton), the predator-prey relationships (the food-web structure), and water temperature, which are in turn dependent on parameters such as water dissolved organic carbon, direct mercury inputs, and ecosystem and climate change (Schartup et al. 2019; Schartup et al. 2018).

While this study is by no means exhaustive, it was meant to provide preliminary information on the contents of some common fishes consumed by local anglers and consumed locally, which can then lead to larger exhaustive studies. For example, ~~Also,~~ long-lived, large and top predators should be analyzed in future campaigns in Kasimedu and other parts of India, as they may have higher concentrations of MeHg and THg (Newland et al. 2006).

4. Conclusions

The study concludes that the concentrations of MeHg in smaller fish species caught off the coast of Chennai may presently be of some concern with respect to health of predatory fish species and lower concern with respect to human health. However, concentrations of THg and MeHg may be adversely impacted by many environmental and climatic parameters in the future. Therefore, continuous monitoring of these, and other species is required to develop a database of contents of mercury in marine biota caught in India, and the subsequent ongoing and future risks for human and wildlife from mercury exposure.

5. Acknowledgements

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6. Declaration of interest

The authors declare no competing interest.

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Table 1. Concentrations of THg and MeHg (µg/kg ww) along with their length, weight and moisture contents in the analyzed marine biota caught by local anglers off the coast of Chennai (Kasimedu), India.

Family	Fish common name	Fish Scientific name	Moisture content (%)	Length of the fish (cm)	Weight of the fish (g)	THg (µg/kg dry weight)	MeHg (µg/kg dw)	MeHg/THg (%)	THg (µg/kg ww)	MeHg (µg/kg ww)
Pelagic										
Clupeidae	Sardine	Sardinella spp.	65.9	11.0	26.0	89.2	65.1	72.9	30.4	22.2
			73.0	14.0	53.0	82.5	50.1	60.8	22.2	13.5
			74.5	6.0	11.0	94.1	93.7	99.5	23.9	23.8
Engraulidae	Anchovy	Stolephorus spp.	71.1	6.0	12.0	67.2	52.2	77.7	19.3	15.0
			73.9	8.0	18.0	58.2	53.5	91.9	15.2	13.9
			77.8	7.0	10.0	91.9	65.3	71.0	20.3	14.5
			79.4	6.0	12.0	28.7	24.3	84.7	5.9	5.0
			71.9	5.0	10.0	43.2	25.6	59.3	12.1	7.1
	Moustached thryssa	Thryssa mystax	83.6	9.0	19.5	154.2	81.6	52.9	25.1	13.3
Carangidae	Yellow tail scad	Atule mate	67.3	9.0	28.0	87.1	83.8	96.2	28.4	27.3
	Shortfin scad	Decapterus macrosoma	74.7	19.0	35.0	176.3	62.6	35.5	44.5	15.8
	Pompano	Trachinotus spp.	63.9	22.0	120.0	26.9	13.4	49.9	9.7	4.8
			83.9	13.0	56.0	123.0	87.5	71.1	19.7	14.0
	Yellow strip trevally	Selaroides leptolepis	70.2	11.0	63.0	78.2	50.3	64.3	23.2	14.9
	Black pomfret	Parastromateus niger	85.1	15.0	32.0	45.2	37.3	82.5	6.7	5.5
	Bluefin Travelly	Caranx melampygus	70.5	14.0	65.0	55.2	38.6	69.8	16.2	11.3

	Crevalle jack	Caranx hippos	80.8	16.0	101.0	145.4	103.6	71.29	27.9	19.8
	Malabar Thryssa	Carangoides malabaricus	77.1	22.0	72.0	61.4	54.8	89.3	14.0	12.5
Scombridae	Indian Mackerel	Rastrelliger spp.	77.6	16.0	67.0	208.3	148.0	71.0	46.4	33.0
			78.3	17.0	96.0	234.4	193.3	82.4	50.7	41.8
Demersal										
Sciaenidae	Croaker	Johnius spp.	77.5	21.0	68.0	435.7	321.9	73.8	97.9	72.3
			75.5	10.0	32.0	131.5	107.4	81.6	32.1	26.2
			83.1	7.0	16.0	104.3	76.3	73.2	17.5	12.8
			80.9	18.0	75.0	136.6	89.3	65.4	25.9	16.9
Dasyatidae	Longtail stingray	Hypanus longus	78.4	26.0	143.0	134.4	111.2	82.7	29.0	24.0
			76.4	20.0	136.0	98.8	96.6	97.7	23.2	22.7
			74.1	14.0	107.0	77.4	73.2	94.5	20.0	18.9
	Blackedge whipray	Himantura marginata	76.5	23.0	138.0	59.0	49.7	84.1	13.8	11.6
			86.2	17.0	62.0	87.3	64.6	73.9	12.0	8.8
Leiognathidae	Pony fish	Leiognathus spp.	67.1	7.0	16.0	64.7	53.6	82.8	21.3	17.6
			81.1	6.0	12.0	78.9	76.3	96.7	14.8	14.3
			85.0	8.0	16.0	89.1	63.3	71.0	13.3	9.4
			66.3	7.0	27.0	55.1	51.6	93.6	18.5	17.3
			69.3	7.0	21.0	37.6	33.5	89.1	11.5	10.2

			73.6	11.0	42.0	102.4	77.6	75.8	27.0	20.4
			77.1	9.0	28.0	34.6	25.6	74.0	7.9	5.8
Cynoglossidae	Tounge fish	Cynoglossus spp.	80.5	20.0	94.0	132.3	94.6	71.5	25.7	18.4
			83.9	12.0	78.0	84.0	81.7	97.2	13.4	13.1
			70.8	11.0	27.0	61.7	37.9	61.4	17.9	11.0
Mullidae	Goat fish	Parupeneus spp.	83.0	8.0	18.0	46.0	34.8	75.6	7.8	5.9
			70.1	21.0	84.0	97.1	75.7	77.9	29.0	22.6
			72.7	16.0	75.0	67.1	48.4	72.0	18.3	13.1
			73.3	11.0	26.0	192.2	155.1	80.7	51.1	41.3
Synodontidae	Lizard fish	Synodus spp.	71.8	16.0	103.0	153.2	116.6	76.2	43.1	32.8
			71.0	6.0	55.0	21.5	13.5	62.8	6.2	3.9
Nemipteridae	Japanese Threadfin Bream	Nemipterus japonicus	81.0	19.0	122.0	110.2	74.4	67.5	20.9	14.1
			68.0	14.0	101.0	89.5	74.1	82.8	28.6	23.7
Loliginidae	Indian Squid Squid	Uroteuthis duvaucelii	73.2	17.0	82.0	72.9	40.3	55.3	19.6	10.8
			85.2	14.0	29.0	34.3	28.1	82.0	5.1	4.1
Lutjanidae	Snapper	Lutjanus spp.	80.0	21.0	56.0	56.3	38.6	68.6	11.3	7.7
			73.5	10.0	39.0	79.4	76.3	96.2	21.0	20.2

Stromateidae	Promfert	Pampus spp.	76.3	15.0	56.0	67.3	63.3	94.1	15.9	15.0
			79.0	16.0	89.0	35.3	23.4	66.3	7.4	4.9
Shellfish										
Portunidae	Sea crab	Portunus sanguinolentus	65.8	15.0	32.0	67.4	54.5	80.9	23.0	18.6
			73.6	12.0	44.0	66.3	50.3	75.8	17.4	13.2
	Mud crab	Scylla serrata	81.9	13.0	69.0	23.2	17.8	76.7	4.1	3.2
Penaeidae	White prawn	Penaeus spp.	82.7	13.0	34.0	81.3	64.6	79.4	14.0	11.1
			70.5	8.0	23.0	103.4	35.5	34.3	30.4	10.4
			75.5	6.0	17.0	101.4	76.3	75.3	24.7	18.6
			72.9	2.0	3.0	227.5	194.0	85.3	61.6	52.5
			84.5	14.0	45.0	34.2	23.3	68.0	5.3	3.6