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DDT concentration in fish from the Tapajós River in the Amazon region, Brazil

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HIGHLIGHTS

- The first study of DDT in fish consumed by the population of the village of Barreiras, Amazon (Brazil).
- DDE/DDT ratio a indicates recent entry of pp′-DDT in fish of Tapajós River.
- Fish samples analyzed were within the limits set by national and international standards for human consumption.

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ABSTRACT

DDT and metabolites were measured in six species of fish collected from the Tapajós River in the village of Barreiras, near the town of Itaituba in the Brazilian Amazon region. The selected fish were the most consumed and economically important to the local people. DDT was used frequently in this region for malaria control. Fish samples were analyzed after extraction by microwave-assisted extraction in hexane/acetone (8:2, v/v) by gas chromatography with electron capture detector. Residues of op′-DDT and pp′-DDT and metabolites were detected, including pp′-DDE, pp′-DDD, op′-DDT, and op′-DDE, in 98% of the samples, with a greater abundance of pp′-DDT. Total DDT levels were 7.1–249.5 ng g^{-1} wet weight (w.w). The DDE/DDT ratio was low, indicating recent exposure to DDT. The study area that may be related to generated waste used in public health campaigns to combat mosquitos (*Anopheles* spp.), still present in the Amazon environment, that transmit malaria. DDT levels and metabolites found in fish species do not present risks to human health because they are below acceptable limits for consumption.

1. Introduction

DDT (1,1,1-trichloro-2,2-di(4-chlorophenyl) ethane) is an organochlorine pesticide classified as one of 12 of the initial persistent organic pollutants (POPs), under the Stockholm Convention for reduction or elimination of these substances in the world (UNEP, 2001). It was used widely for several years in Brazil to combat the transmission malaria vector. The first use of DDT was in 1945 in the town of Breves in Pará State (Ferreira et al., 2011). In the 1990s, approximately 600,000 annual cases of malaria were reported in Brazil, with over 99% of the cases concentrated in the Amazon region (Brasil, 2006). Brazil acquired approximately 3000 tons of DDT for malaria control (D'Amato et al., 2002). They have also been implicated in the mechanisms involved in breast, testicular, and prostate cancer (Romieu et al., 2000; ATSDR, 2002; Carreño et al., 2007; Eskenazi et al., 2009; El-Shahawi et al., 2010; Cohn, 2011); central nervous system and behavioral effects; sexual dysfunction; and estrogenic and anti-androgenic activity (ATSDR, 2002; Asawasinsopon et al., 2006; Galassi et al., 2008; Sharma et al., 2009). DDT is a semi-volatile compound with low water solubility. It can be stored in plants and in fatty tissues of mammals, fish, and birds (Li et al., 2008; Llop et al., 2010). It adheres to soil and has low degradability, but in the environment DDT is decomposed to DDE (1,1-dichloro-2,2-bis(4-chlorophenyl) ethylene) and DDD (1,1-dichloro-2,2-bis(4-chlorophenyl) ethane), which have properties similar to DDT (D'Amato et al., 2002; Cal et al., 2008). These chemicals were listed because of their ability to bioaccumulate in adipose tissue as they move up the food web, as well as their high

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environmental persistence and lipid solubility. The persistence of these compounds is caused by their low degradability, which results in a long half-life in the environment, where it can persist for many years, contaminating the soil and aquatic organisms (Jones and de Voogt, 1999; Turusov et al., 2002).

Fish are indicators of environmental pollution in aquatic systems (Fisk et al., 2001), because they are sensitive to changes in various environments, are at or near the top of the food web, can accumulate large amounts of pollutants in their tissues, and are therefore subject to bioconcentration and biomagnification processes (Mackay and Fraser, 2000; Rognerud et al., 2002). The determination of DDT and other organochlorines in fish is indicative of contamination in aquatic biota and reflects the state of persistent chemical compounds in the environment (Fisk et al., 2001; Darko et al., 2008). DDT is highly toxic to aquatic life, including several fish species (Foran and Cox, 1989; WHO, 1989.). In Brazil, approximately 45% of the fish and bivalve mollusks has quantifiable concentrations of persistent (Bisinoti et al., 2007).

The goal of this study was to determine levels of DDT and its metabolites in edible fish from the basin of the Tapajós River in the village of Barreiras in the city of Itaituba, Pará State, Brazil. We also assessed whether these levels posed health risks to the human population living next to the river where fish consumption is important in their diet.

2. Materials and methods

2.1. Study area

The Tapajós River is a major tributary of the Amazon River when combined with the Juruena River, it is approximately 2000 km long. The village of Barreiras is located approximately 90 km north of the city of Itaituba (Figure 1). The local people in this village are economically dependent on Amazonian fish, although the village is located in one of the main gold mining areas of the Amazon region (Harada et al., 2001). This area is also considered an endemic area for malaria and yellow fever, diseases transmitted to humans by mosquitoes (*Anopheles* spp.). In the 1990s, this area was sprayed at least twice a year with DDT (Torres et al., 2002). Access to the river is difficult and preferably by boat, across the Tapajós River or by land along a municipal road for a distance of ≥70 km. The resident population is approximately 1000 people with permanent residences, and 154 families distributed in 196 houses built along four streets.

2.2. Sampling

147 fish were collected belonging to six species in dry season, in as shown in Table 1. Length of the collected fish was 14–47 cm and weighed 200–1300 g. We removed 100 g of muscle tissue for chemical analysis and determination of concentrations of DDT metabolites. The samples were placed in plastic bags to prevent contamination, carefully labeled, and transported in thermal containers with ice bricks for subsequent laboratory analysis. Prior to analysis, samples were homogenized, packed in amber glass, and stored at −20 °C.

2.3. Extraction and analysis

Analytical standards of pp′-DDT, pp′-DDE, pp′DDD, op′-DDT, op′-DDE and op′-DDD were acquired from ChemService (West Chester, PA, USA). High purity reagents and solvents (pesticides grade solvents) were obtained from Merck (Darmstadt, Germany). The standard reference material (SRM 1974, Fish Tissue) with certificate of analysis was obtained from the National Institute of Standards & Technology (NIST, Gaithersburg, MD, USA).

The extraction of DDT and metabolites was performed by microwave assisted extraction (MAE) using the Mars Xpress

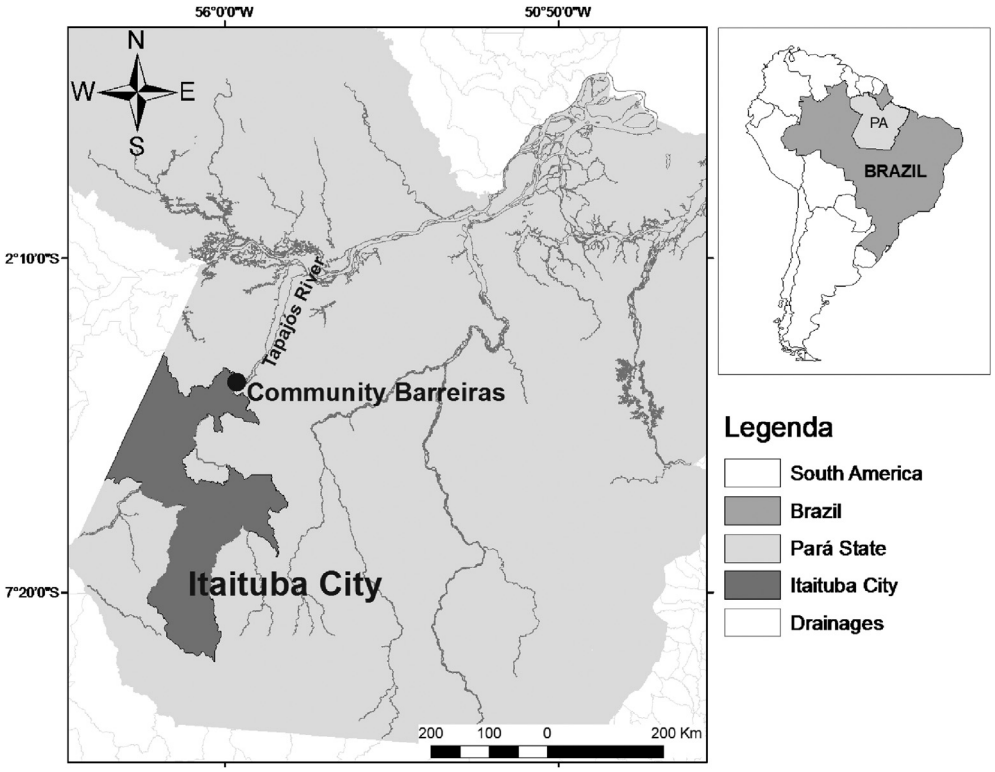

Fig. 1. Geographical location of the study area.