Human Exposure to Mercury as a Consequence of Landscape Management and Socio-Economical Behaviors. Part I: The Brazilian Amazon Case Study

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Abstract: The presence of mercury (Hg) in the environment has become a source of great concern in the scientific community throughout the World. However, existing models describing Hg behavior in the environment and risks to community's health attributable to Hg exposure fail to cope with the complexity of this issue and the social perception of concerned populations. Through the IDRC (International Development Research Center)-supported CARUSO project, we have developed over the last ten years a unique participatory research project dealing with the presence of mercury in aquatic resources of Brazilian Amazon. Our interdisciplinary research first produced breakthrough scientific findings such as 1) identifying deforestation and soil erosion as the main source of mercury away from gold mining zones, and 2) witnessing early health alterations in riparian communities related to consumption of Hg-loaded fish. Now in a more advanced stage of our project, we use our scientific findings along with a bottom-up approach with pilot communities to realize intervention and empowerment projects. Such projects aim at short-term improvement of human health (shift in food consumption patterns) and long-term restoration of the environmental equilibrium (slow-down of deforestation with a shift to more sustainable agricultural practices). The scaling up of our activities from a series of pilot projects to a concerted Regional intervention at the scale of an entire watershed is presently is underway with the creation of an ambitious network regrouping representatives of local communities (unions, NGO's), stakeholders from local, state and federal governmental institutions, and key decision makers of international organisms.

Keywords: mercury contamination, slash-and-burn-agriculture, human health, Brazilian Amazon, sustainable development.

INTRODUCTION

The Tapajós River area, located to the West of the state of Pará in the Brazilian Amazon, is a very active pioneer front. Between 1970 and 1991, the population of Santarém urban area doubled while that of Itaituba, located 300 km upstream Santarém, went ten-fold[1]. This strong demographic pressure translates into a rapid transformation of forested areas in cultivated lands, a process which began close to the riverbanks many decades ago and is currently affecting areas more and more remote from the river. Lumbering activities and gold mining operations are also taking places in specific areas of the region, the latter activity being associated with mercury released in the environment. This study addresses the sources and the fate of mercury contamination in varied compartments of the environment and its effects of human health for local inhabitants, through participatory and interdisciplinary research based on an ecosystem approach.

RESULTS AND DISCUSSION

Concerned about the effects of mercury on human health in the Amazon and supported by IDRC (International Development Research Centre), researchers from UFPa (Universidade Federal do Pará) in Belém, Brazil, and UQAM (Université du Québec à Montréal) in Montreal, Canada, teamed up in 1994 to explore the problem in the Tapajós River region, where thousands of miners have panned for gold over the last 30 years. The team first collected and analyzed the burdens of Hg in water at intervals along the river, starting 50 km downstream from the gold mining sites and ending 350 km away in the Santarém area. The researchers found that concentrations were relatively constant along the Tapajós River, thus suspecting a major source of mercury other than gold mining[2].

Analysis of lacustrine sediments from the river-floodplain system as well as of river-bed sediments from the wider river-lake region downstream Aveiro showed that the most recent layers contained 1.5 to 3 times more mercury than layers deposited 40 years ago, even 400 kilometers downstream of the gold-mining sites, indicative of a generalized Hg contamination[3]. Sampling and analysis of nearby soils revealed high mercury concentrations throughout entire soil profiles down to 1-m depth, and a decrease was observed in cultivated soils[4]. The researchers thus concluded that deforestation linked to slash-and-burn agricultural practices has allowed rain to erode soils of the river watershed, coupled with soil lixiviation processes through water percolation, transferring high Hg loads into the aquatic ecosystems. Indeed, analysis of terrigenous organic matter in sediments confirmed a shift in the nature of the organic matter eroded from terrestrial systems in relation to land-use changes[5]. Once mercury is released in river, lakes, and other aquatic environments, bacteria can transform the mercury into its organic form, highly toxic methylmercury. The team suspects that the igapós flooded forests and the large mats of floating macrophytes that are a specific feature of this Amazonian region are key sites of this transformation[6], leading to its absorption by aquatic fauna, which increases in concentration as it moves up the food chain and then to humans.

People living along the Tapajós depend on fish for a major part of their diet. The research team analyzed hair, blood and urine samples from fish-consuming villagers who live near the river and conducted simple coordination test on them to determine the impact of measured methylmercury on their health. These tests showed that they had experienced declines in coordination, manual dexterity and certain visual functions at hair mercury levels well below the accepted international threshold of 50 mg/g[7]. Furthermore, cytogenetic damage was detected under similar low mercury contamination[8]. As a whole, the mercury problem affects the adult population as well as in utero child. These results serve an early warning that more serious neurological and immunology problem could develop among the region's population. The explanation of mercury contamination based on deforestation and soil erosion is consistent with the recent history of the Tapajós River basin. Some decades ago, immigrants from Northern Brazil had begun to colonize the area, slashing and burning trees on lands located along the river in preparation for cropping and other activities. Land degradation is now omnipresent along the whole Tapajós watershed, this area still being an active deforestation front due to the settlement of thousands of *sem terra* (landless people), favored by national policies of Brazil.

Research activities then shifted towards broader environmental and human perspectives, including intervention strategies based on capacity building. Firstly, an intervention project aiming at shifting towards consumption of less contaminated fish species was conducted in the village of Brasilia Legal. Indeed, mercury bioaccumulation in aquatic ecosystems is related to fish species, the mercury content in carnivorous species being six times higher than in the herbivorous ones[9]. Through education based on posters showing the status of mercury contamination in relation to the fish species (Figure 1), the change in diet habits resulted in a reduction of close to 40 % of hair mercury level over 5 years. Moreover, relationships between varied consumed food and mercury exposure in this study have shown that the consumption of at least one fruit per day of specific fruit species was having a protective effect against mercury exposure[10]. Characterization of social networks is important in capacity building. Such a study conducted in the village of Brasília Legal emphasized the influence of certain community groups in knowledge transfer, namely fishermen and health workers. On the other hand, farmers were shown to be rather isolated. Given the key role these latter actors play in the process of soil erosion, land-use changes were studied in the floodplain area around the village of Brasilia Legal, in relation with human, economic and environmental factors. These anthropogenic actions proved to have an impact on soil fertility and mercury concentrations. At that point, workshops with varied farming communities of the area were conducted to discuss the relationships between successions of cultivated crops and the loss of soil fertility as well as with mercury contamination processes. The use of posters (Figures 2 and 3) allowed to understand that fire was perceived as a low-labor method to clear the land, the fertilizing effects coming from the burning of the vegetation biomass being unknown.

CONCLUSIONS

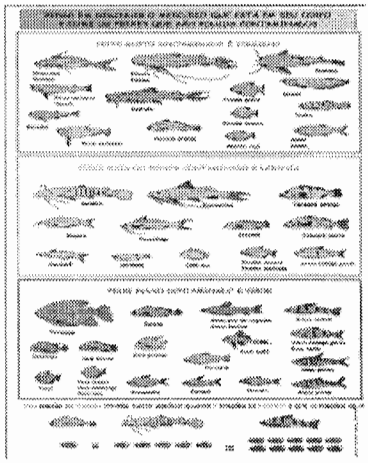

Figure 1. Capacity building: Fish species and mercury

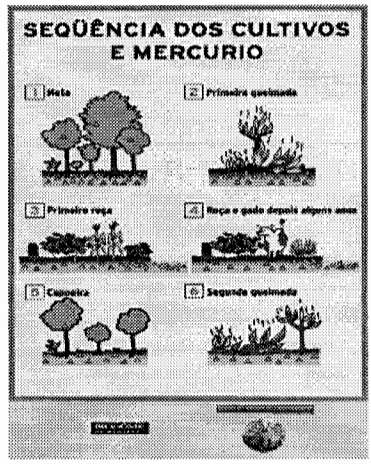

Figure 2. Capacity building: Agriculture and mercury

Agriculture practices based on slash-and-burn have been associated with the release of mercury naturally contained in Amazonian soils into aquatic ecosystems, where it transforms into its toxic organic form, methylmercury, and is absorbed by aquatic fauna, affecting human health through fish consumption. Although intervention activities could and are currently implemented to reduce the consumption of more contaminated fish species, a longer term intervention relies in promoting less erosive agricultural practices on farms located on riversides, this activity being above the problem of mercury contamination. To do so, our team is presently active at scaling up its research-intervention activities to the Regional level, considering the highly disturbed region of the watershed of the Tapajós River between São Luis do Tapajós and Aveiro, which represents over 40 small communities spread out along a 150 km stretch south-north by around 50 km width on each side of the river, directing agricultural practices towards a better land

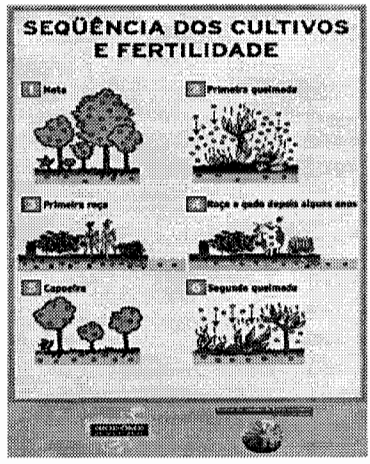

Figure 3. Capacity building: Agriculture and soil fertility

management in order to protect and restore highly significant ecosystems from the Amazon and to improve the quality of life of ever poor farmers in this region. An efficient strategy should address the problem using a coherent and integrated ecosystem approach, gathering together communities, universities and government agencies.

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