Chemical and petrochemical industry site: Coatzacoalcos region in Mexico.

Mercury levels in fish in the Coatzacoalcos River

IPEN Mercury-Free Campaign Report

Prepared by Ecología y Desarrollo Sostenible en Coatzacoalcos, A.C. and Centro de Análisis y Acción en Tóxicos y sus Alternativas – CAATA (Mexico), Arnika Association (Czech Republic) and the IPEN Heavy Metals Working Group

Coatzacoalcos – Mexico City – 3 April 2013

Introduction

In 2009, the Governing Council of the United Nations Environment Programme (UNEP GC) decided to develop a global legally binding instrument on mercury to reduce risks to human health and the environment (UNEP GC25/5). The UNEP GC noted that mercury is a substance of global concern due to its long-range transport, persistence, ability to bioaccumulate, and toxicity. Its conclusions were based in part on the 2002 UNEP Global Mercury Assessment which noted that mercury is present in fish all over the globe at levels that adversely affect humans and wildlife (UNEP 2002).

This report is based on analyses of mercury levels in fish in the Coatzacoalcos river in the area of Coatzacoalcos-Minatitlán, Veracruz State, Mexico, where a chlor-alkali plant and waste incinerator are located inside of a petrochemical complex, and where an oil and gas refinery is located. Levels of mercury in hair of population living in this area were examined in our previous report published in January 2013 (Ecología y Desarrollo Sostenible en Coatzacoalcos, CAATA *et al.* 2013).[1]

In addition, since local mercury releases become global problems due to long-range transport we considered how the draft treaty text will address these sources.

Chemical and petrochemical industry in the Coatzacoalcos – Minatitlán area

The municipality of Coatzacoalcos, located in the southern state of Veracruz, is included in the so-called Olmec region, comprising 25 municipalities and dominated by the cities of Coatzacoalcos and Minatitlán. The area has a population of nearly two million and comprises approximately 41% of the economic activity in the state.

There are two main industrial sources of mercury pollution in the study area; a chlor-alkali plant inside of a petrochemical complex near the city of Coatzacoalcos (which also includes a waste incinerator) and an oil and gas refinery in Minatitlán.

The chlor-alkali plant is Industrias Químicas del Itstmo, S.A. (IQUISA), which is part of a company group named Cydsa. The facility began chlorine production in 1968 using mercury cell technology. In 1981, Cloro de Tehuantepec (Mexichem) began operation using mercury but currently employs diaphragm cells and does not release mercury in their discharges.

[1] See Mexico in Country Hot Spot Report at http://ipen.org/hgmonitoring/

The oil and gas refinery known as General Lázaro Cárdenas refinery was established in 1906, as the first major refinery in Latin America. A reconfiguration of the refinery was completed in 2011 to increase the processing capacity of crude oil to 350,000 barrels per day (BPD), an increase in the percentage of Maya crude.

In addition to the chemical production facilities, two incinerators were operating in the Pajaritos petrochemical complex at different times in the period of 1995 – 2002. The units burned chemical industry by-products and one incinerator had a capacity to burn 1.5 tons per hour (approximately 100 tons at day). A third incinerator started its operation in 2005 and burns mainly the wastes from vinyl chloride monomer (VCM) production.

Other potential sources of mercury emissions include private chemical industries established in the three petrochemical complexes (Pajaritos, Cangrejera and Morelos). In addition, there are regional hospitals and crematoria located in the area.

? ??????????? ??????

Ecología y Desarrollo Sostenible en Coatzacoalcos, A.C. conducted sampling of fish in cooperation with local fishermen using protocols developed by BRI (2011). Fifteen fish samples were taken in total for this study in the Coatzacoalcos - Minatitlán area (See map at Figure 1). Biodiversity Research Institute (BRI) measured mercury levels (total mercury content = THg) in fish samples in their laboratory in Gorham, Maine, USA. Ecologia y Desarrollo Sostenible en Coatzacoalcos, A.C. and CAATA characterized the site and provided information about its history and presumptive mercury sources.

Figure 1: Map of Coatzacoalcos – Minatitlán region with marked location  of the fish sampling sites.

?

Results and discussion

There is extensive literature on the presence of mercury in aquatic ecosystems in the area of Coatzacoalcos and some measurements of mercury in fish and hair. However, most of the data is 35 years old and there is no publically available clinical or epidemiological assessment of the impacts on the population. In these previous studies, the Minatitlán Refinery has never been considered as a possible source of mercury releases nor has its contribution to mercury content in fish or humans in the region been considered. According to Lang, Gardner, Holmes (2012) global concentrations of mercury in crude oil and gas range from 0.1 to 20.000 mg/kg in crude oil and 0.05 to 5000 mg/m^3 of natural gas. Acosta *et al.* (2001) note that it is likely that most of the mercury in present in crude oil processed in refineries in Mexico, although a portion of it could be passed to the lighter fractions as diesel or gas generated in the atmospheric cooling tower.

For this study, three fish species were sampled from two different localities in the Coatzacoalcos river (see map at Figure 1): common snook (robalo blanco; *Centropomus undecimalis*), fat snook (chucumite; *Centropomus paralellus*) and gafftopsail catfish (bandera o banderilla; *Bagre marinus).* Table 1 shows the levels of mercury (Hg) in each species of fish.

Table 1: Mercury content of fish sampled in the Coatzacoalcos River in the area of Coatzacoalcos – Minatitlán, Mexico.

	Sample Size	Hg Average (ppm, ww)	St Dev	Min Hg (ppm)	Max Hg (ppm)	Reference dose[2] (ppm)	Fraction of samples over Ref. Dose
All fish samples	15	0.258	0.065	0.155	0.395	0.22	67%
Common snook	3	0.268	0.062	0.197	0.314	0.22	67%
Fat snook	3	0.306	0.096	0.205	0.395	0.22	67%
Gafftopsail catfish	9	0.239	0.053	0.155	0.339	0.22	67%

Abbreviations: Hg, mercury; ppm, parts per million or mg/kg; ww, wet weight; min, minimum; max, maximum

The results in Table 1 show that the mean mercury level in all 15 fish samples is higher than the US EPA reference dose of 0.22 ppm. Fish containing mercury concentrations of 0.22 parts per million (ppm) should be consumed no more than once per month [3] Two thirds of fish samples had mercury levels higher than the reference dose. The maximum mercury value

[2] Figure derived from the reference dose used as U.S. EPA consumption guidelines for fish (0.2 mg.kg^{-1} methylmercury) based on the presumption that methylmercury counts for 90% of THg levels, limit value used by Canada is similar . Japan and/or UK use 0.3 reference dose. Source: US EPA (2001). Water Quality Criterion for the Protection of Human Health: Methylmercury. Final. EPA-823-R-01-001, Office of Science and Technology, Office of Water, U.S. Environmental Protection Agency Washington, DC**:** 303.

[3] Based on the U.S. EPA's reference dose of 0.0001 mg methylmercury per kg of body mass per day, BRI calculated fish consumption guidelines using an average body mass of 60 kg (132 pounds) and an average fish mealsize of 170 grams (6 ounces). Fish containing mercury concentrations of 0.22 parts per million (ppm) should be consumed no more than once per month. Fish with mercury concentrations less than this value (<0.22 ppm) can be consumed more frequently. Fish with mercury concentrations greater than 0.95 should be avoided. Entirely. For more information see Appendix: Methods Behind the data in Global Mercury Hotspots BRI-IPEN Jan 2013. at http://ipen.org/hgmonitoring/pdfs/ipen-bri-report-global-hg-hostpots-2013-01-09.pdf

observed in the fish samples from Coatzacoalcos – Minatitlán area was observed in fat snook and exceeded the US EPA reference dose by 1,8-fold.

Báez *et al.* (1976) noted mercury in fish muscles in higher levels than observed in our study. For common snook levels of 0.20 to 0.97 ppm ww values reported in 1973 and 0.08-1.7 ppm ww in 1974. In ground croaker (ronco; *Bairdiella ronchus)* they reported even higher levels of mercury 0.45-3.54 ppm ww.

Guentzel, Portilla *et al*. (2007, 2011) performed measurements of mercury in people living near the Alvarado lagoon system as well as fish from this ecosystem. Concentrations of total Hg in fish and shellfish harvested from the Alvarado lagoon systém ranged from 0.01 to 0.35 ppm ww: chucumite (*Centropomus parallelus* (0.152 ± 0.034 ppm ww) striped mojarra (*Eugerres plumieri* (0.35 ppm ww) and shellfish (brown shrimp (*Penaeus aztecus* (0.008 ± 0.001 ppm ww) and brown crab (*Callinectes rathbunae* (0.026 ± 0.002 ppm ww).

The concentration of mercury in muscle tissue of the hardhead catfish (*ariopsis felis*) in the southern Gulf of Mexico (between the years 2001-2004) ranged from <0.006 to 0.157 ppm dry weight (Vázquez, Florville-Alejandre et al. 2008). Range of mercury dry weight of fish in samples from our study ranged between from 0.640 to 1.920 ppm dw and thus it can be considered as higher levels however in other fish species than hardhead catfish.

Recently there were found very high levels of mercury in fish from Mexico in carp with mean of 0.87 ppm ww in the study focused on Lake Chapala, Jalisco state (Trasande, Cortes *et al.* 2010).

The transport of mercury in the atmosphere was inferred by Báez (1976) in Coatzacoalcos acid rain from air emissions generated by the 3 petrochemical complexes of Morelos, Pajaritos and Cangrejera that are carried by wind currents prevailing in the region of Coatzacoalcos going south and southeast.

Chlor-alkali plants using mercury, oil refinery, and waste incinerators in the mercury treaty

The chemical industry hotspot in the Coatzacoalcos – Minatitlán area provokes questions about how the mercury treaty might mandate actions to eliminate mercury pollution of the environment and fish from chlor-alkali facilities along with releases from other significant sources of mercury pollution.

More recent studies by (Pirrone, Cinnirella et al. 2010); (Mukherjee, Bhattacharya *et al.* 2009) estimate that the chlor-alkali sector produces 3-times higher total mercury releases to air than original the UNEP Chemicals (2008) air emissions inventory, while global releases to water caused by chlor-alkali plants were not estimated at all. These findings as well as case documented in this study underline need to set up an early date for phasing out mercury use in chlorine production, but from the two options (2020 or 2025) in proposed treaty text (UNEP (DTIE) 2012)[4] the later one was negotiated at last INC (Intergovernmental Negotiating Committee) meeting on future Mercury treaty. It will permit continued use of mercury for a long time.

[4]**UNEP**(DTIE)/Hg/INC.5/3; Two phase out dates options bracketed in Annex D Part I: Processes subject to Article 7, paragraph 2.

To prevent continuous mercury pollution of the Coatzacoalcos – Minatitlán area including all water ecosystems and people depending on these ecosystems it is necessary to prevent further releases from the chemical industry complex, wastes and especially stop the use of mercury in chlorine production.

Significant levels of mercury were found also near the oil refinery in Minatitlán, which has increased processing capacity of crude oil to 350,000 barrels per day (BPD), equivalent to an increase of 188.7% in the production. This may lead to significant increases in mercury emissions in the broader region of Coatzacoalcos- Minatitlán according to US EPA (2001) and recent findings in UK (Lang, Gardner *et al*. 2012). The current treaty text does not address emissions of mercury from oil refineries (UNEP (DTIE) 2012);[5] however, it is necessary to establish strict control of mercury emissions in this sector.

We recommend that health authorities conduct regular fish monitoring for mercury in the Coatzacoalcos Basin and develop a consumer alert strategy, with the participation of relevant academia, NGOs, and social organizations including those potentially affected by mercury in fish.

We also recommend that environmental federal authorities ensure that new industrial facilities do not utilize mercury catalysts. An example is the new petrochemical complex, Ethylene S XXI, under construction in the Nanchital Municipality near Coatzacoalcos, Veracruz with Mexican and Brazilian investment. The project is planned to produce 1 million of tons a year of ethylene and polyethylene in three polymerization plants beginning in 2015.[6] However, the recently adopted Mercury Treaty discourages this type of manufacturing process in which mercury is used.[7]

Until these problems are addressed, mercury will continue to contaminate both the local area and contribute to global mercury pollution.

Acknowledgements:

Ecología y Desarrollo Sostenible en Coatzacoalcos, A.C., CAATA, Arnika Association and IPEN gratefully acknowledges the financial support the governments of Sweden and Switzerland, and others, as well as the technical support provide by the Biodiversity Research Institute (BRI) to analyze the data. The content and views expressed in this report, however, are those of the authors and IPEN and not necessarily the views of the institutions providing financial and/or technical support.

[5] **UNEP**(DTIE)/Hg/INC.5/3; Oil and gas production and processing facilities was in brackets in Annex F proposal with not threshold proposed . Finnaly, all the sector was taken out of the scope of the Mercury treaty in the final negotiated text.

[6] See http://www.grupoidesa.com/es/content/etileno-xii

[7] http://www.unep.org/hazardoussubstances/Mercury/Negotiations/INC5/INC5Report/tabid/3496/Default.aspx

References

Acosta, I., et al., (2001). Inventario Preliminar de Emisiones Atmosféricas de Mercurio en México. Informe Final. Agua Prieta, Sonora, México**:** 93.

Báez, A. P., R. Nulman, I. Rosas and L. Gálvez (1976). "Aquatic organism contamination by mercury residues in the Coatzacoalcos River Estuary, Mexico." International Atomic Energy Agency, Viena: 73-99.

BRI (2011). Standard Operating Procedure for Fish Tissue Sampling. Global Fish & Community Mercury Monitoring Project. Gorham, Maine, USA, BioDiversity Research Institute**:** 14.

Ecología y Desarrollo Sostenible en Coatzacoalcos, CAATA, Arnika Association and IPEN Heavy Metals Working Group (2013). Chemical and petrochemical industry site: Coatzacoalcos region in Mexico. Coatzacoalcos - Mexico City, Prepared by Ecología y Desarrollo Sostenible en Coatzacoalcos, A.C. and Centro de Análisis y Acción en Tóxicos y sus Alternativas – CAATA (Mexico) and Arnika Association (Czech Republic) and the IPEN Heavy Metals Working Group**:** 7.

Guentzel, J. L., E. Portilla, K. M. Keith and E. O. Keith (2007). "Mercury transport and bioaccumulation in riverbank communities of the Alvarado Lagoon System, Veracruz State, Mexico." Science of The Total Environment **388**(1–3): 316-324.

Guentzel, J. L., E. Portilla, Ortega-Argueta, A., B.E. Cortina-Julio, Keith, E. O. (2011). The Alvarado Lagoon-Environment, Impact, and Conservatión. Capitulo 14, Pp397-415. In: Friedman, G. (ed). Lagoons Biology, Management and Environmental Impact . Hauppauge NY: Nova Science Publishers, Inc.

Lang, D., M. Gardner and J. Holmes (2012). Mercury arising from oil and gas production in the United Kingdom and UK continental shelf, IKIMP - Mercury Knowledge Exchange; University of Oxford. Department of Earth Sciences. South Parks Road, Oxford, Reino Unido. **:** 42.

Mukherjee, A., P. Bhattacharya, A. Sarkar and R. Zevenhoven (2009). Mercury emissions from industrial sources in India and its effects in the environment. Mercury Fate and Transport in the Global Atmosphere. R. Mason and N. Pirrone, Springer US**:** 81-112.

Pirrone, N., S. Cinnirella, X. Feng, R. B. Finkelman, H. R. Friedli, J. Leaner, R. Mason, A. B. Mukherjee, G. B. Stracher, D. G. Streets and K. Telmer (2010). "Global mercury emissions to the atmosphere from anthropogenic and natural sources." Atmospheric Chemistry and Physics Discussions **10**: 4719-4752.

Trasande, L., J. E. Cortes, P. J. Landrigan, M. I. Abercrombie, R. F. Bopp and E. Cifuentes (2010). "Methylmercury exposure in a subsistence fishing community in Lake Chapala, Mexico: an ecological approach." Environmental Health **9**(1).

UNEP (2002). Global Mercury Assessment. Geneva, Switzerland, UNEP**:** 258.

UNEP (DTIE) (2012). UNEP(DTIE)/Hg/INC.5/3: Draft text for a global legally binding instrument on mercury. Chair's draft text. Intergovernmental negotiating committee to prepare a global legally binding instrument on mercury - Fifth session - Geneva, 13– 18 January 2013, United Nations Environment Programme**:** 44.

UNEP Chemicals Branch (2008). The Global Atmospheric Mercury Assessment: Sources, Emissions and Transport. Geneva, UNEP - Chemicals**:** 44.

US EPA (2001). Mercury in Petroleum and Natural Gas: Estimation of Emissions from Production, Processing, and Combustion. Research Triangle Park, NC 27711, Prepared for Office of Air Quality Planning and Standards, and by National Risk Management, Research Laboratory

US EPA (2001). Water Quality Criterion for the Protection of Human Health: Methylmercury. Final. EPA-823-R-01-001, Office of Science and Technology, Office of Water, U.S. Environmental Protection Agency Washington, DC**:** 303.

Vázquez, F., T. R. Florville-Alejandre, M. Herrera and L. M. D. de León (2008). "Metales pesados en tejido muscular del bagre Ariopsis felis en el sur del golfo de México (2001-2004) - Heavy metals in muscular tissue of the catfish, Ariopsis felis, in the southern Gulf of Mexico (2001-2004)." Lat. Am. J. Aquat. Res. **36**(2): 223-233.