

Environmental factors influencing mercury speciation in subarctic and Boreal lakes

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Environmental drivers of total mercury (TotHg) concentrations, methylmercury (MeHg) concentrations, and MeHg fractions (a proxy for methylation potential, expressed as %MeHg) were assessed in a synoptic study of 51 lakes in southeast (Boreal) and northeast (Subarctic) Norway. Concentrations of TotHg and MeHg ranged between 0.566.6 ng/L and < 0.0260.70 ng/L, respectively. The lakes span wide ranges of explanatory environmental variables, including water chemistry, catchment characteristics, climate conditions, and atmospheric deposition of Hg, sulphur and nitrogen (N). Dissolved organic matter (DOM), measured as total organic carbon (TOC), was the variable most strongly correlated with TotHg ($r^2 = 0.76$) and MeHg ($r^2 = 0.64$) concentrations. Lakes in the Subarctic region had significantly lower TotHg and MeHg concentrations, and %MeHg than lakes in the Boreal region ($p < 0.01$), implying a lower aquatic food web exposure of aqueous Hg species in Subarctic Norway than in the Boreal lakes. Statistical modelling (partial least squares) using data from the Boreal lakes produced models explaining 82%, 75% and 50% of the spatial variation of TotHg and MeHg concentrations and %MeHg, respectively. After TOC, the most significant explanatory variables were N availability, base cation status, and lake and catchment size. We conclude that a key process driving TotHg concentrations is DOM as a transport vector, while the role of DOM for MeHg and %MeHg is likely related to a combination of transport and DOM as a substrate for methylation. Also, negative correlations between MeHg, and catchment and lake size are consistent with in-lake and in-stream demethylation processes. The statistical relationship suggests that N availability exerts a positive contribution on concentrations of MeHg and %MeHg.

The Minamata Convention on Mercury: Attempting to address the global controversy of dental amalgam use and mercury waste disposal

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Journal: Science of the Total Environment, 15 February 2014, Volume 472, 1256129

In October 2013, a new international binding treaty instrument called the Minamata Convention on Mercury opened for signature in Minamata City, Japan, the site of arguably the worst public health and environmental disaster involving mercury contamination. The

treaty aims to curb the significant health and environmental impacts of mercury pollution and includes provisions addressing the mining, export and import, storage, and waste management of products containing mercury. Importantly, a provision heavily negotiated in the treaty addresses the use of dental fillings using mercury amalgam, an issue that has been subject to decades of global controversy. Though use of dental amalgam is widespread and has benefits, concerns have been raised regarding the potential for human health risk and environmental damage from emissions and improper waste management. While the Minamata Convention attempts to address these issues by calling for a voluntary phase-down of dental amalgam use and commitment to other measures, it falls short by failing to require binding and measurable targets to achieve these goals. In response, the international community should begin exploring ways to strengthen the implementation of the dental amalgam treaty provisions by establishing binding phase-down targets and milestones as well as exploring financing mechanisms to support treaty measures. Through strengthening of the Convention, stakeholders can ensure equitable access to global oral health treatment while also promoting responsible environmental stewardship.

Influence of the pore structure and surface chemical properties of activated carbon on the adsorption of mercury from aqueous solutions

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Journal: Marine Pollution Bulletin, , 15 January 2014, Volume 78(1-2), 69676

Reactivation and chemical modification were used to obtain modified activated carbons with different pore structure and surface chemical properties. The samples were characterized by nitrogen adsorption-desorption, Fourier transform infrared spectroscopy and the Boehm method. Using mercury chloride as the target pollutant, the Hg^{2+} adsorption ability of samples was investigated. The results show that the Hg^{2+} adsorption capacity of samples increased significantly with increases in micropores and acidic functional groups and that the adsorption process was exothermic. Different models and thermodynamic parameters were evaluated to establish the mechanisms. It was concluded that the adsorption occurred through a monolayer mechanism by a two-speed process involving both rapid adsorption and slow adsorption. The adsorption rate was determined by chemical reaction.

Organohalogen contaminants and total mercury in forage fish preyed upon by thick-billed murre in northern Hudson Bay

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Journal: Marine Pollution Bulletin, 15 January 2014, Volume 78(1-2), 2586266

Twelve marine fish species collected from a thick-billed murre (*Uria lomvia*) breeding colony in northern Hudson Bay in the Canadian Arctic during 2007-2009 were analyzed for legacy organochlorines (e.g. PCBs, DDT), polybrominated diphenyl ethers (PBDEs), perfluorinated carboxylates (PFCAs) and sulfonates (PFASs), and total mercury (Hg). No one species of prey fish had the highest levels across all contaminant groups analyzed. For the two pelagic fish species sampled, concentrations of the major organochlorine groups (e.g. Σ PCB, DDT, CHL, CBZ), PBDE, PFCA and Hg were consistently higher in Arctic cod (*Boreogadus saida*) than in capelin (*Mallotus villosus*). Biomagnification factors from whole fish to thick-billed murre liver across all species were generally higher for Σ PCB and DDT. PBDE did not biomagnify.

Mercury in the sediments of the Marano and Grado Lagoon (northern Adriatic Sea): Sources, distribution and speciation

Author: Alessandro Acquavita, Stefano Covelli, Andrea Emili, Daniela Berto, Jadran Faganeli, Michele Giani and Milena Horvat.

Journal: Estuarine, Coastal and Shelf Science, 10 November 2012, Volume 113, 20631

The existence of mining tailings in Idrija (Slovenia) and their subsequent transportation via the Isonzo River has been the primary source of mercury (Hg) in the northern Adriatic Sea for almost 500 years, making the Gulf of Trieste and the adjacent Marano and Grado Lagoon two of the most contaminated marine areas in the world. A further, more recent, contribution of Hg has been added by the operation of a chlor-alkali plant (CAP) located in the drainage basin flowing into the Lagoon. On the basis of previous research, as well as new data obtained from the "MIRACLE" project (Mercury Interdisciplinary Research for Appropriate Clam farming in a Lagoon Environment), the spatial distribution of Hg and its relationships with methylmercury (MeHg), organic matter and several geochemical parameters in surface sediments were investigated. The predominant and long-term impacts of the cinnabar-rich Isonzo River particulate matter in the Lagoon surface sediments are evident and confirmed by a decreasing concentration gradient from east ($>11 \text{ g g}^{-1}$) to west (0.7 g g^{-1}). Hg originated from the CAP is only significant in the central sector of the Lagoon. Hg is primarily associated with fine-grained sediments ($<16 \text{ m}$), as a consequence of transport and dispersion from the fluvial source through littoral and tidal currents. However, speciation analyses highlighted the presence of Hg sulphides in the coarse sandy fraction of sediments from the eastern area, as expected given the origin of the sedimentary material. Unlike Hg, the distribution of MeHg ($0.47\text{--}7.85 \text{ ng g}^{-1}$) does not show a clear trend. MeHg constitutes, on average, 0.08% of total Hg and percentages are comparable to those obtained in similar

lagoon environments. Higher MeHg concentrations in low to intermediate Hg-contaminated sediments indicate that the metal availability is not a limiting factor for MeHg occurrence, thus suggesting a major role played by environmental conditions and/or speciation. The reasonably good correlation between MeHg normalized to humic acid (HA) content and humic $\delta^{13}\text{C}$ indicates that MeHg is preferentially associated with autochthonous $\delta^{13}\text{C}$ -enriched HAs in lagoon surface sediments, suggesting that the structure of marine HAs, less refractory and less aromatic, could favor MeHg binding and/or production. In the context of the potential hazard of Hg and MeHg accumulation in reared clams, the choice of a site for the extension of farming activities inside the Marano and Grado Lagoon is dependent on several factors and cannot be decided solely on the basis of the total Hg content in the sediment.

A screening model analysis of mercury sources, fate and bioaccumulation in the Gulf of Mexico

Author: Reed Harris, Curtis Pollman, David Hutchinson, William Landing, Donald Axelrad and Steven L. Morey.

Journal: Environmental Research, January 2013, Volume 119, 53663.

A mass balance model of mercury (Hg) cycling and bioaccumulation was applied to the Gulf of Mexico (Gulf), coupled with outputs from hydrodynamic and atmospheric Hg deposition models. The dominant overall source of Hg to the Gulf is the Atlantic Ocean. Gulf waters do not mix fully however, resulting in predicted spatial differences in the relative importance of external Hg sources to Hg levels in water, sediments and biota. Direct atmospheric Hg deposition, riverine inputs, and Atlantic inputs were each predicted to be the most important source of Hg to at least one of the modeled regions in the Gulf. While incomplete, mixing of Gulf waters is predicted to be sufficient that fish Hg levels in any given location are affected by Hg entering other regions of the Gulf. This suggests that a Gulf-wide approach is warranted to reduce Hg loading and elevated Hg concentrations currently observed in some fish species. Basic data to characterize Hg concentrations and cycling in the Gulf are lacking but needed to adequately understand the relationship between Hg sources and fish Hg concentrations.

Deciphering the impact of land-uses on terrestrial organic matter and mercury inputs to large boreal lakes of central Québec using lignin biomarkers

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Journal: Applied Geochemistry, February 2014, Volume 41, 34648

To evaluate watershed impacts of anthropogenic activities on terrestrial organic matter (TOM) and total mercury (THg) dynamics in large boreal lake ecosystems, we studied sediment cores retrieved in eight large lakes of Québec (Canada). Two lakes with pristine watersheds were considered as reference lakes and six lakes with watersheds affected by different types of anthropogenic activities (e.g. logging and/or mining activities) were used to illustrate the influence of land-use on TOM and Hg cycling in lakes. A Geographical Information System (GIS) approach was used to correlate the evolution of anthropogenic land-uses from 1979 to 2010 (e.g. logging and mining activities) to TOM and THg contents measured in sediment cores. In each core, THg concentrations gradually increased over the recent years. Using lignin biomarkers, we noticed that the presence of both intense logging and mining activities in the watershed does not necessarily correspond to noticeable changes in the relative amount of terrestrial organic matter (TOM) exported from the watershed to the sediments and by extension to the level of THg measured in sediments. Apparently large-scale watersheds show some buffering capacity to land-use disturbance

Selenium speciation, distribution, and transport in a river catchment affected by mercury mining and smelting in Wanshan, China

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Journal: Applied Geochemistry

Selenium (Se) is an important co-existing elemental component of the mineral matrix of mercury (Hg) ore deposits. The hazards associated with Se contamination of the aquatic ecosystems in Hg mining areas; however, are often overlooked by environmental researchers due to a preoccupation with Hg. Selenium may also pose a long-term risk to the local ecosystem, and further complicate the situation as Se may also play an important antagonistic role against Hg. Furthermore, most studies on Se pollution have focused only on total Se, whereas the toxicity, bioavailability, and bioaccumulation of Se in aquatic ecosystems is primarily determined by its site-specific individual species. In this study, the concentrations of total Se, inorganic Se (tetravalent and hexavalent), and organic Se were determined in water samples collected from 41 typical sites selected in rivers, tributaries, and springs in Wanshan, China, where Hg and Se co-occur due to historic Hg mining and retorting activities. Se concentrations were observed to decrease with distance from mine-waste calcines, which indicated that mine-waste calcines may be significant sources of the elevated Se in the rivers, especially in downstream areas within 8 km from the mine-waste calcines. The concentration of total aqueous Se throughout the study area was highly variable

($3.8 \pm 6.0 \text{ g L}^{-1}$) and on average was one order of magnitude greater than that in natural river systems worldwide ($0.16\text{--}0.3 \text{ g L}^{-1}$). The majority of the Se was hexavalent ($3.1 \pm 4.9 \text{ g L}^{-1}$; 65%), followed by tetravalent ($0.53 \pm 0.86 \text{ g L}^{-1}$; 15%) and organic forms ($0.85 \pm 1.5 \text{ g L}^{-1}$; 20%), possibly due to the generally alkaline conditions. Se concentrations in some sampling sites exceeded certain recommended limit of values. However, the existing criteria for Se in aquatic system are mainly based on total Se and the recommended limit of values in different countries or organizations are inconsistent with one another. Therefore, the need to consider Se speciation rather than only total Se is highlighted for future studies.

Evidence for microbially mediated production of elemental mercury (Hg^0) in subarctic lake sediments

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Journal: Applied Geochemistry, October 2013, Volume 37, 1426148

The production and fate of Hg^0 in lake sediments remains poorly characterized, although it can potentially influence Hg toxicity and mobility. Using slurry incubations, we assessed the effect of nutrients, pH, ionic strength, and tested the role of microbes, on Hg^0 production from pristine lake sediments of the Hudson Bay Lowlands in Ontario, Canada. We showed that Hg^0 production from oxygenated sediments was low (<1% of the Hg flux to sediments), biogenic, and did not appear to be dependent on the predicted Hg^{II} speciation in the slurry. The addition of biologically labile carbon sources and ionic strength, particularly $[\text{Na}^+]$, had the greatest impact on Hg^0 production, increasing it by over 10-fold. These results suggest that under changing conditions, such as increasing temperature or alteration of water chemistry as observed in numerous locations throughout Arctic and subarctic environments, a fraction of sedimentary Hg may be remobilized and available for microbial reduction.

Methylmercury in Biota Downstream of Arivaca Lake, Arizona, USA

Author: Carrie L. H. Marr, Kathy Robertson and Kevin D. Reynolds.

Journal: Environmental Contamination and Toxicology, January 2014, Volume 14, 12618

Concentrations of total mercury (Hg) and methylmercury (MeHg) were determined in water, sediment, periphyton, spiders, and amphibians from the streams and desert marsh downstream from Arivaca Lake, Arizona, to better understand their distribution and bioaccumulation. Mean concentrations of MeHg in water ranged from 0.09 to 0.93 ng/L, and mean concentrations of total Hg in sediment ranged from 10.4 to 126 g/kg. Hg and MeHg in water and sediments downstream from Arivaca Lake were low enough that they did not

exceed human health or ecological thresholds. Hg and MeHg between sites ranged from 0.11 to 1.90 g/g Hg and 0.01 to 0.3 g/g MeHg in periphyton, from 0.09 to 0.25 g/g Hg and 0.04 to 0.10 g/g MeHg in spiders, and from 0.15 to 0.38 g/g Hg and 0.14 to 0.35 g/g MeHg in adult bullfrogs. No Hg toxicity data exist for periphyton or spiders, but MeHg concentrations in tadpoles (0.04 ± 0.005 g/g) were lower than those known to cause sublethal effects and subchronic mortality. The mean total Hg concentration in adult bullfrogs in the present study was 0.24 g/g, which is slightly lower than the mean (0.37 g/g) from an Hg-contaminated wetland in California. MeHg bioaccumulated at each successive trophic level, and MeHg bioconcentration factors from the Arivaca watershed were similar to those for periphyton but greater than amphibians in other studies. Local resource managers can use these data to determine if water should be released from Arivaca Lake to recharge the aquifer downstream or to decrease Hg methylation in the reservoir.

Low-Level Experimental Selenite Additions Decrease Mercury in Aquatic Food Chains and Fish Muscle but Increase Selenium in Fish Gonads

Author: Mariah Mailman, R. A. Bodaly, Michael J. Paterson, Shirley Thompson and Robert J. Flett

Journal: Archives of Environmental Contamination and Toxicology, January 2014, Volume 66(1),32-40

We investigated whether low-level addition of selenium (Se) could decrease mercury (Hg) in freshwater fish without imposing Se toxicity. Using a regression design, selenite was added to large mesocosms in a lake to achieve target concentrations 0.6 g/L. ^{198}Hg (spike Hg) was added to mesocosms to determine changes in Hg bioaccumulation. Adding Se decreased spike total Hg (THg) in fish muscle, ambient THg in fish liver, and bioaccumulation of spike THg in muscle and spike methylmercury (MeHg) in zooplankton and *Chironomid* larvae relative to controls. Se decreased Hg in the food web but not in water, indicating that the dominant effect of Se on Hg cycling occurs in the food web. Concentrations of Se in gonads of fish were positively correlated with Se concentrations in water but did not exceed reproductive toxicity thresholds after 8 weeks. We conclude that low-level addition of Se decreases MeHg bioaccumulation and increases Se in gonads of fish; however, additions of Se to freshwater systems to decrease Hg in fish should be treated with caution because Se in fish gonads were likely to exceed toxic concentrations if exposed to increased Se for a longer period of time.

Assessment of Nonlethal Methods for Predicting Muscle Tissue Mercury Concentrations in Coastal Marine Fishes

Author: Maria N. Piraino and David L. Taylor

Journal: Environmental Contamination and Toxicology, November 2013, Volume 65(4), 715-723

Caudal fin clips and dorsolateral scales were analyzed as a potential nonlethal approach for predicting muscle tissue mercury (Hg) concentrations in marine fish. Target fish were collected from the Narragansett Bay (Rhode Island, USA) and included black sea bass *Centropristis striata* [$n = 54$, 14655 cm total length (TL)], bluefish *Pomatomus saltatrix* ($n = 113$, 31673 cm TL), striped bass *Morone saxatilis* ($n = 40$, 346102 cm TL), summer flounder *Paralichthys dentatus* ($n = 64$, 18655 cm TL), and tautog *Tautoga onitis* ($n = 102$, 27661 cm TL). For all fish species, Hg concentrations were greatest in muscle tissue [mean muscle Hg = 0.4761.18 mg/kg dry weight (dw)] followed by fin clips (0.0360.09 mg/kg dw) and scales (0.0160.07 mg/kg dw). The coefficient of determination (R^2) derived from power regressions of intraspecies muscle Hg against fin and scale Hg ranged between 0.35 and 0.78 (mean $R^2 = 0.57$) and 0.1460.37 (mean $R^2 = 0.30$), respectively. The inclusion of fish body size interaction effects in the regression models improved the predictive ability of fins ($R^2 = 0.6360.80$; mean = 0.71) and scales ($R^2 = 0.3360.71$; mean = 0.53). According to the high level of uncertainty within the regression models (R^2 values) and confidence interval widths, scale analysis was deemed an ineffective tool for estimating muscle tissue Hg concentrations in the target species. In contrast, the examination of fin clips as predictors of muscle Hg had value as a cursory screening tool; however, this method should not be the foundation for developing human consumption advisories. It is also noteworthy that the efficacy of these nonlethal techniques was highly variable across fishes and likely depends on species-specific life-history characteristics.

Mercury levels in myliobatid stingrays (Batoidea) from the Gulf of California: tissue distribution and health risk assessment

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Journal: Environmental Monitoring and Assessment, March 2014, Volume 186 (3), 1931-1937

With the aim of knowing Hg distribution in selected tissues of myliobatid stingrays and assessing health risk to Mexican population, Hg concentration was determined in the muscle and liver of four ray species. Total Hg levels were determined by cold vapor atomic absorption spectrophotometry. With respect to the muscle, devil rays (*Mobula* spp.) showed

lower Hg levels ($<0.22 \text{ g g}^{-1}$) than *Rhinoptera steindachneri* ($0.37 \pm 0.25 \text{ g g}^{-1}$ wet weight). In the case of the liver, the highest Hg concentration was found in *Mobula japonica* ($0.22 \pm 0.01 \text{ g g}^{-1}$). Hg levels in the muscle and liver varied according to the species; in some cases, the liver accumulated more Hg than the muscle and the opposite pattern in other cases. *R. steindachneri* showed a significant difference between both tissues. No significant differences of Hg levels between males and females and between juveniles and adult specimens of *R. steindachneri* were found. Positive correlation between Hg concentrations and disc width and total weight was not significant for *R. steindachneri* ($R_s < 0.36, p > 0.05$). Batoids showed Hg values below the Mexican (NOM-027-SSA1-1993) limits (1.0 g g^{-1}) in fishes for human consumption. The species with the highest potential of Hg transfer to human population is *R. steindachneri*; however, an adult (70 kg) could consume approximately 943 g per week without representing a health risk. Nevertheless, further and continuous monitoring is needed since batoids support an important fishery in Mexican waters, being a food resource and income to coastal communities.

Health risk assessment of mercury and arsenic associated with consumption of fish from the Persian Gulf

Author: Mehdi Raissy and Mahsa Ansari .

Journal: Environmental Monitoring and Assessment , February 2014, Volume 186 (2), 1235-1240

Concentrations of mercury and arsenic in fish from the Persian Gulf were determined by graphite furnace atomic absorption spectrometry. Concentrations of the metals in muscle samples were $0.04960.402 \text{ g g}^{-1}$ for mercury and $0.16860.479 \text{ g g}^{-1}$ for arsenic, with means of 0.133 and 0.312 g g^{-1} , respectively. The maximum daily consumption rate (grams per day) and meal consumption limit (meals per month) was calculated to estimate health risks associated with fish consumption. According to the results, the maximum allowable consumption rate varies between 8656 and 15696 g/day based on mercury and arsenic content, respectively. The results of this study indicate that the concentration of mercury and arsenic is well below the maximum permissible levels for mercury (0.5 g g^{-1}) and arsenic (6 g g^{-1}) according to international standards.

Mercury in the sediments of Vembanad Lake, western coast of India

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Journal: Environmental Monitoring and Assessment , January 2014, Volume 65 (4), 715-723

Mercury, a global pollutant, is popping up in places where it was never expected before and it burdens in sediments and other non-biological materials. It is estimated to have increased up to five times the pre-human level due to anthropogenic activities. Vembanad backwaters, one of the largest Ramsar site in India, which have extraordinary importance for its hydrological function, are now considered as one of the mercury hot spots in India. In this study, surface sediment samples of Vembanad Lake and nearshore areas have been seasonally analysed for total mercury and methyl mercury concentrations while the core sediment samples were analysed for total mercury. The results showed that the northern part of the lake was more contaminated with mercury than the southern part. The mercury concentration was relatively high in the subsurface sediment samples, indicating the possibility of historic industrial mercury deposition. A decreasing trend in the mercury level towards the surface in the core sediment was also observed. The geochemical parameters were also analysed to understand the sediment mercury chemistry. Anoxic conditions, pH and organic carbon, sulphur and Fe determined the presence of various species of mercury in the sediments of Vembanad Lake. The prevailing physical and geochemical conditions in Vembanad Lake have indicated the chances of chemical transformation of mercury and the potential hazard if the deposited mercury fractions are remobilised.

Concentrations of particulates in ambient air, gaseous elementary mercury (GEM), and particulate-bound mercury (Hg(p)) at a traffic sampling site: a study of dry deposition in daytime and night-time

Author: Guor-Cheng Fang, Yen-Heng Lin, Chia-Ying Chang and Yu-Cheng Zheng

Journal: Environmental Geochemistry and Health, November 2013, Volume 40, 1610.

In this investigation, the concentrations of particles in ambient air, gaseous elemental mercury (GEM), and particulate-bound mercury (Hg(p)) in total suspended particulates (TSP) as well as dry deposition at a (Traffic) sampling site at Hung-kuang were studied during the day and night in 2012. The results reveal that the mean concentrations of TSP in ambient air, GEM, and Hg(p) were 69.72 g/m^3 , 3.17 , and 0.024 ng/m^3 , respectively, at the Hung-kuang (Traffic) sampling site during daytime sampling periods. The results also reveal that the mean rates of dry deposition of particles from ambient air and Hg(p) were $145.20 \text{ g/m}^2 \text{ min}$ and $0.022 \text{ ng/m}^2 \text{ min}$, respectively, at the Hung-kuang (Traffic) sampling site during the daytime sampling period. The mean concentrations of TSP in ambient air, GEM, and Hg(p) were 60.56 g/m^3 , 2.74 , and 0.018 ng/m^3 , respectively, at the Hung-kuang (Traffic) sampling site during the nighttime sampling period. The mean rates of dry deposition of particles and

Hg(p) from ambient air were 132.58 g/m² min and 0.016 ng/m² min, respectively, at the Hung-kuang (Traffic) sampling site during the nighttime sampling period.

A compilation of field surveys on gaseous elemental mercury (GEM) from contrasting environmental settings in Europe, South America, South Africa and China: separating fads from facts

Author: Pablo Higueras, Roberto Oyarzun, JozeKotnik, José MaríaEsbrí, Alba Martínez-Coronado, Milena Horvat and Willians Llanos

Journal: Environmental Geochemistry and Health, December 2013, Volume 113, 20631

Mercury is transported globally in the atmosphere mostly in gaseous elemental form (GEM, Hg⁰gas), but still few worldwide studies taking into account different and contrasted environmental settings are available in a single publication. This work presents and discusses data from Argentina, Bolivia, Bosnia and Herzegovina, Brazil, Chile, China, Croatia, Finland, Italy, Russia, South Africa, Spain, Slovenia and Venezuela. We classified the information in four groups: (1) mining districts where this contaminant poses or has posed a risk for human populations and/or ecosystems; (2) cities, where the concentration of atmospheric mercury could be higher than normal due to the burning of fossil fuels and industrial activities; (3) areas with natural emissions from volcanoes; and (4) pristine areas where no anthropogenic influence was apparent. All the surveys were performed using portable LUMEX RA-915 series atomic absorption spectrometers. The results for cities fall within a low GEM concentration range that rarely exceeds 30 ng m⁻³, that is, 6.6 times lower than the restrictive ATSDR threshold (200 ng m⁻³) for chronic exposure to this pollutant. We also observed this behavior in the former mercury mining districts, where few data were above 200 ng m⁻³. We noted that high concentrations of GEM are localized phenomena that fade away in short distances. However, this does not imply that they do not pose a risk for those working in close proximity to the source. This is the case of the artisanal gold miners that heat the Au-Hg amalgam to vaporize mercury. In this respect, while GEM can be truly regarded as a hazard, because of possible physicochemical transformations into other species, it is only under these localized conditions, implying exposure to high GEM concentrations, which it becomes a direct risk for humans.

Exposure assessment of heavy metals (Cd, Hg, and Pb) by the intake of local foods from Zhejiang, China

Author: Jun Tang, Zhu Huang and Xiao-Dong Pan

Journal: Environmental Geochemistry and Health, January 2014, Volumes 47, 3366345

Considering the environmental pollution, food safety is of great concern to the consumers. The present study was conducted to assess the health risk of cadmium (Cd), mercury (Hg), and lead (Pb) through the dietary intake in Zhejiang, China. Eight hundred and sixty two food samples including aquatic products, meat, vegetables, milk and dairy products, and cereal grains were analyzed. Only 2.44 % (Cd), 1.39 % (Hg), and 1.51 % (Pb) of the samples exceeded the maximum allowable concentration set by Chinese Ministry of Health. The average dietary intakes of Cd, Hg, and Pb were estimated to be 0.26, 0.14, and 0.55 g/kg bw/day, respectively. Compared with the reference doses, the mean exposure of Cd, Hg, and Pb was all less than the tolerable intake value. Only at the 95th percentile level, Cd and Hg exposure exceeded the values of tolerable intakes by 40 and 277 %, respectively. It indicates that there is low health risk to the dietary exposure of Cd, Hg, and Pb for general people in Zhejiang province, China.

Long-distance transport of Hg, Sb, and As from a mined area, conversion of Hg to methyl-Hg, and uptake of Hg by fish on the Tiber River basin, west-central Italy

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Orlando Vaselli and Pierfranco Lattanzi

Journal: Environmental Geochemistry and Health, February 2014, Volume 36(1), 145-157

Stream sediment, stream water, and fish were collected from a broad region to evaluate downstream transport and dispersion of mercury (Hg) from inactive mines in the Monte Amiata Hg District (MAMD), Tuscany, Italy. Stream sediment samples ranged in Hg concentration from 20 to 1,900 ng/g, and only 5 of the 17 collected samples exceeded the probable effect concentration for Hg of 1,060 ng/g, above which harmful effects are likely to be observed in sediment-dwelling organisms. Concentrations of methyl-Hg in Tiber River sediment varied from 0.12 to 0.52 ng/g, and although there is no established guideline for sediment methyl-Hg, these concentrations exceeded methyl-Hg in a regional baseline site (<0.02 ng/g). Concentrations of Hg in stream water varied from 1.2 to 320 ng/L, all of which were below the 1,000 ng/L Italian drinking water Hg guideline and the 770 ng/L U.S. Environmental Protection Agency (USEPA) guideline recommended to protect against chronic effects to aquatic wildlife. Methyl-Hg concentrations in stream water varied from <0.02 to 0.53 ng/L and were generally elevated compared to the baseline site (<0.02 ng/L). All stream water samples contained concentrations of As (<1.066.2 g/L) and Sb (<0.206 0.37 g/L) below international drinking water guidelines to protect human health (10 g/L for As and 20 g/L for Sb) and for protection against chronic effects to aquatic wildlife

(150 g/L for As and 5.6 g/L for Sb). Concentrations of Hg in freshwater fish muscle ranged from 0.052 to 0.56 g/g (wet weight), mean of 0.17 g/g, but only 17 % (9 of 54) exceeded the 0.30 g/g (wet weight) USEPA fish muscle guideline recommended to protect human health. Concentrations of Hg in freshwater fish in this region generally decreased with increasing distance from the MAMD, where fish with the highest Hg concentrations were collected more proximal to the MAMD, whereas all fish collected most distal from Hg mines contained Hg below the 0.30 g/g fish muscle guideline. Data in this study indicate some conversion of inorganic Hg to methyl-Hg and uptake of Hg in fish on the Paglia River, but less methylation of Hg and Hg uptake by freshwater fish in the larger Tiber River.

Mercuric chloride induced toxicity responses in the olfactory epithelium of *Labeorohita* (HAMILTON): a light and electron microscopy study

Author: Debasree Ghosh and Dipak Kumar Mandal

Journal: Fish Physiology and Biochemistry, February 2014, Volume 40(1), 83-92

Bioaccumulation of mercury and histomorphological changes in the olfactory epithelium of *Labeorohita* were investigated after exposing the fish to two sublethal concentrations of HgCl₂ (66 and 132 g/L) for 15 and 30 days. Mercury deposition increased in the tissue significantly ($p < 0.05$) with dose- and duration-dependent manner. Severe damage to the olfactory epithelium was evident. When fish exposed to 66 g/L for 15 days, the histology of olfactory epithelium exhibited that mucous cell proliferation was upregulated and cell size was significantly increased from the control. Similar trends were found in 30 days exposure in both treated groups. Histology showed that mercury induced degeneration of columnar sensory cells, supporting cells and ciliated non-sensory cells and induced basal cell proliferation. Basal cell hyperplasia led to form intraepithelial proliferative lesion, thickening of epithelium, basal lamina disruption and cyst formation. Scanning electron microscopy revealed that mercury exposure at 66 g/L caused clumping and loss of cilia, erosion in microridges on the supporting cells and proliferation of mucous cell opening. Complete degeneration of ciliated cells and cyst formation was observed in the fish when exposed to 132 g/L HgCl₂. This result suggests that prolonged exposure to mercury might cause irreversible damage to the olfactory epithelium and impair the olfactory function of fish.

Mercury distribution in target organs and biochemical responses after subchronic and trophic exposure to Neotropical fish *Hopliasmalabaricus*

Author: Maritana Mela, Francisco Filipak Neto, Flávia Yoshie Yamamoto, Ronaldo Almeida, Sonia Regina Grötzner and Dora Fix Ventura,

Journal: Fish Physiology and Biochemistry , February 2014, Volume 40 (1), 245-256

In the present study, we investigated the mercury distribution, mercury bioaccumulation, and oxidative parameters in the Neotropical fish *Hopliasmalabaricus* after trophic exposure. Forty-three individuals were distributed into three groups (two exposed and one control) and trophically exposed to fourteen doses of methylmercury each 5 days, totalizing the doses of 1.05 g g⁻¹ (M1.05) and 10.5 g g⁻¹ (M10.5 group). Autometallography technique revealed the presence of mercury in the intestinal epithelia, hepatocytes, and renal tubule cells. Mercury distribution was dose-dependent in the three organs: intestine, liver, and kidney. Reduced glutathione concentration, glutathione peroxidase, catalase, and glutathione S-transferase significantly decreased in the liver of M1.05, but glutathione reductase increased and lipid peroxidation levels were not altered. In the M10.5, most biomarkers were not altered; only catalase activity decreased. Hepatic and muscle mercury bioaccumulation was dose-dependent, but was not influenced by fish sex. The mercury localization and bioaccumulation corroborates some histopathological findings in this fish species (previously verified by Mela et al. in *Ecotoxicol Environ Saf* 68:426-435, 2007). However, the results of redox biomarkers did not explain histopathological findings previously reported in M10.5. Thus, fish accommodation to the stressor may reestablish antioxidant status at the highest dose, but not avoid cell injury.

Oxidative stress status, antioxidant metabolism and polypeptide patterns in *Juncusmaritimus* shoots exhibiting differential mercury burdens in Ria de Aveiro coastal lagoon (Portugal)

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This study assessed the oxidative stress status, antioxidant metabolism and polypeptide patterns in salt marsh macrophyte *Juncusmaritimus* shoots exhibiting differential mercury burdens in Ria de Aveiro coastal lagoon at reference and the sites with highest, moderate and the lowest mercury contamination. In order to achieve these goals, shoot-mercury burden and the responses of representative oxidative stress indices, and the components of both non-

glutathione- and glutathione-based H₂O₂-metabolizing systems were analyzed and cross-talked with shoot-polypeptide patterns. Compared to the reference site, significant elevations in *J. maritimus* shoot mercury and the oxidative stress indices such as H₂O₂, lipid peroxidation, electrolyte leakage and reactive carbonyls were maximum at the site with highest followed by moderate and the lowest mercury contamination. Significantly elevated activity of non-glutathione-based H₂O₂-metabolizing enzymes such as ascorbate peroxidase and catalase accompanied the studied damage-endpoint responses, whereas the activity of glutathione-based H₂O₂-scavenging enzymes glutathione peroxidase and glutathione sulfotransferase was inhibited. Concomitantly, significantly enhanced glutathione reductase activity and the contents of both reduced and oxidized glutathione were perceptible in high mercury-exhibiting shoots. It is inferred that high mercury-accrued elevations in oxidative stress indices were obvious, where non-glutathione-based H₂O₂-decomposing enzyme system was dominant over the glutathione-based H₂O₂-scavenging enzyme system. In particular, the glutathione-based H₂O₂-scavenging system failed to coordinate with elevated glutathione reductase which in turn resulted into increased pool of oxidized glutathione and the ratio of oxidized glutathione-to-reduced glutathione. The substantiation of the studied oxidative stress indices and antioxidant metabolism with approximately 53-kDa polypeptide warrants further

Styrofoam debris as a potential carrier of mercury within ecosystems

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Journal:Environmental Science and Pollution Research , February 2014, Volume 21(3), 2263-2271.

The present paper falls within the trend of research into interactions between various pollutants emitted anthropogenically into the environment and focuses on mercury and styrofoam debris. The study covers part of the Southern Baltic's drainage area. Apart from styrofoam and beach sand, the research involved mosses, which are bioindicators of atmospheric metal pollution. The research has shown that mercury present in the environment becomes associated with styrofoam debris. The median for mercury concentrations in virgin styrofoam samples (0.23 ng g⁻¹ dry weight (d.w.)) and in beach sand samples (0.69 ng g⁻¹ d.w.) was an order of magnitude lower than in the styrofoam debris (5.20 ng g⁻¹ d.w.). The highest mercury content observed in styrofoam debris (3,863 ng g⁻¹ d.w.) exceeded the standards for bottom sediment and soil. The binding of mercury to styrofoam debris takes place in water, and presumably also through contact with the ground. A significant role in

this process was played by biotic factors, such as the presence of biofilm and abiotic ones, such as solar radiation and the transformations of mercury forms related to it. As a result, mercury content in styrofoam debris underwent seasonal changes, peaking in summertime. Furthermore, the regional changes of mercury content in the studied debris seem to reflect the pollution levels of the environment.

Evaluation of mercury biotransformation by heavy metal-tolerant

***Alcaligenes* strain isolated from industrial sludge**

Author: S. Gupta and J. Nirwan

Journal: International Journal of Environmental Science and Technology, January 2014, Volume 2, 63-71.

Heavy metal pollution affects environment adversely and leads to severe implications for both flora and fauna. In the present work, bacterial strain JS-1 was isolated with tolerance for different metals such as mercury (Hg), lead (Pb), cadmium (Cd), nickel (Ni), arsenic (As), tin (Sn), selenium (Se), zinc (Zn), chromium (Cr) and copper (Cu). JS-1 showed a significant tolerance for mercuric chloride (up to 5,000 g/g) along with an efficient metal uptake and transformation. Growth of JS-1 was marginally affected on exposure to high mercury concentration due to acclimatization of the culture towards mercury. No mercury was found in cell-free supernatant after 96 h of incubation with 500 g/g and 1,000 g/g of mercury as an active ingredient. Almost all the mercury was found associated with cell biomass as determined by hydride generation atomic absorption spectroscopy. Only 60 % of mercury was sequestered in bacterial biomass on exposure to 2,000 and 5,000 g/g mercury. As a detoxification mechanism, nearly 5 % of sequestered mercury was volatilized by the selected isolate (JS-1). Further X-ray diffraction analysis of deposited silvery grey biomass confirmed biotransformation of sequestered mercuric ions into monovalent mercury (Hg_2Cl_2), a non-bioavailable form of mercury. Culture was characterized morphologically, physiologically and biochemically. 16S rRNA gene sequence of JS-1 revealed its phylogenetic relationship and 98 % homology with *Alcaligenes faecalis*, a Gram-negative rod-shaped bacterium.

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