Nahua People of Santa Rosa de Serjali and mercury exposure

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We reviewed the mercury in urine and creatinine data generated by Peruvian health authorities(CENSOPAS a,b, 2015; DSGSP/MINSA, 2015; MINSA, 2015; Tang Flores, 2015), and a power point presentation titled "Monitoreo Ambiental y de Peces para Determinación de Presencia de Mercurio Acción en Santa Rosa de Serjali" (Monitoring of fish and the environment to determine presence of mercury in Santa Rosa de Serjali) by the Ministry of the Environment and offer the following testimony.

Background information

Two types of mercury can be present in the body: organic and inorganic. Inorganic mercury coming from industrial exposure (e.g., gold mining, fossil fuel exploration and combustion including combustion of biomass) predominantly deposits in the kidneys whereas, organic mercury (or methylmercury) from the diet will deposit in muscle tissues and the brain. The pathways by which mercury enters the body are through inhalation, ingestion, or dermal absorption.

Methylmercury is a neurotoxin affecting the functions of the central nervous system, and is the organic form of mercury that is of the greatest hazard to human health. Exposure to humans and wildlife is mostly through the diet of fish and other animals that bioaccumulate and biomagnify methylmercury through the food web. The half-life of mercury in the adult body is 45-70 days therefore, prospective mothers can reduce their body burden by avoiding exposure for 6-12 months prior to pregnancy.

Acute exposure to high concentrations of inorganic mercury vapors can also result in damage to the nervous, digestive, renal, and respiratory systems. Chronic exposure damages the central nervous system causing diseases such as arrhythmias, cardiomyopathies, and can result in loss of memory.

Blood and hair are useful for quantifying dietary exposure to the toxic methylmercury form because 80% to 100% of the total mercury found in them is methylmercury. Thus, the less expensive lab test for total mercury ($45/sample), instead of the more costly methylmercury analysis ($120/sample), in blood or hair can provide necessary information about an individual's methylmercury concentrations. Urine total mercury (corrected for creatinine) is a good indicator of **inorganic mercury** exposure because the majority of the total mercury in urine is present in the inorganic form. Although this analysis may help assess detrimental effects on kidney function, it is not as useful in evaluating exposure to organic mercury through diet. Importantly, urine analysis for total mercury is useful in diagnosing acute exposure but it is recommended to collect the urine over a 24 - hour period.

Urine concentrations in Nahua people

According to the Centro Nacional de Salud Ocupacional y Protección del Medio Ambiente para la Salud (CENSOPAS), 156 urine samples were collected and analyzed for total mercury in males and females ranging in age from < 1 year old to greater than 60 years old from the community of Santa Rosa de Serjali during the period November 2014 to October 2015. These samples were not collected over a 24-hour period as recommended by the medical profession and World Health Organization (WHO). Nevertheless, notable exceedances of acceptable levels were observed in this population. Of the 156 people tested, 132 individuals (85%) had concentrations greater than 5 μg total Hg/g creatinine and 4 people exceeded 50 μg/g, the **maximum** urine creatinine mercury concentration set by WHO (1991). Of the 156 people, 91 (58%) had urine mercury (not corrected for creatinine) exceeding the normal value of 9 ng/mL.

Mercury urine levels rarely exceed 5 μg/g creatinine in persons who are not occupationally exposed to mercury (UNIDO, 2003b). Mercury concentrations in urine below **9 ng/mL (ppb)** or **0.009 μg/mL (ppm**) are considered normal. Normal concentrations in blood are <10 ng/mL. Levels above 10 - 20 μg/L (or ng/ml), indicate excessive exposure. Neurological effects are likely if the concentration is above 100 μg/L, but symptoms may occur at much lower levels, down to 5 - 10 μg/L.

Lacking in the analyses to date is a determination of whether or not the people of Santa Rosa de Serjali are also exposed to methylmercury through their diet of fish. Analysis of hair can reflect organic mercury exposure over a longer period. Furthermore, hair is logistically easy to sample and store, and it does not require special handling or trained medical personnel to collect. Blood samples could also be informative but are more complicated to collect, store and analyze.

Routes of exposure

Exposure to **inorganic** mercury can result from natural sources (e.g. volcanoes) (Bargagli and Barghigiani 1991) or industrial activities such as gold mining (WHO 2008,Yard et al. 2012), coal fired power plants, (Peroni et al. 2010, Roos-Barraclough 2002) or specifically mining and production of mercury (Pacyna and Pacyna 2002). Natural gas may contain small amounts of mercury but the element is normally removed from the raw gas during the recovery of liquid constituents and during the removal of hydrogen sulfide (Pirrone et al. 2001b). In the case of the source of exposure to the residents of the community of Santa Rosa de Serjali, our evaluation indicates that gold mining is not practiced near the community in the watershed. There is a severe mercury contamination problem in Madre de Dios region (Yard et al. 2012) but it is in a different watershed – approximately 250 km from the village of Santa Rosa de Serjali therefore is unlikely to be the source of mercury contamination amongst the Nahua (see attached mapå) (Fernandez 2013).

However, the source of **mercury contamination could be many kilometers upstream** from the village. An old mercury mine (to the best of our knowledge) is located in Huancavelica, ~450 km southeast of Lima. Although it is an unlikely source of mercury in the Urubamba River watershed, it should be evaluated as a potential source of the contamination. A possible, but unstudied, source of the identified inorganic mercury exposure detected in Santa Rosa de Serjali residents could be a result of the natural gas exploration or improper removal and disposal of mercury during the recovery in the region.

As recommended by the Ministry of Environment, biotic monitoring should also be conducted to test various types and sizes of fish consumed by the local residents. Predatory fishes such as mota punteada (*Colophysus macropterus*) or moteada, are (Dr. Conrad Feather personal communication) an important part of the local diet. These are higher trophic level predators and could have high mercury concentrations. A few fish from the **Mishagua and Serjali** Rivers in the **Urubamba basin** were tested and **several had elevated Hg concentrations.** The results of SANIPES state, "…the consumption of fish C*alophysus macropterus* constitutes one of the sources or routes of exposure to **inorganic Hg**". We believe this was in error and should have been stated as "…sources of exposure to **organic Hg**" . Because approximately 90% of the total mercury in fish is in the organic or methyl form, analysis for total mercury in fish is adequate as an indicator of methyl mercury exposure but not inorganic mercury exposure. The catfish (mota) from Rios Mishagua and Serjali had reported (total) Hg concentrations high enough (0.4 - 0.6 ppm) and often exceeding the maximum limit of 0.5 μg/g established for human consumption; a cause for concern in people who consume this fish on a regular basis (WHO 2007). This same species of catfish tends to show high Hg concentrations in other parts of its range in South America (Salinas et al. 2014) likely because of its predatory and scavenger feeding strategy.

Activities associated with natural gas exploration in the region could be the original source of mercury measured in the urine of Santa Rosa de Serjali residents and in the Mishagua and Serjali River fishes and should be evaluated. The Camisea project (see attached map) and processing to remove mercury (Malvinas plant) in the reserve occupied by the Nahua and is now operating approximately 30 - 40 km as the crow flies south and upstream of the Nahua's village including in new exploratory wells on the Upper Serjali river basin that have been explored since the start of 2015 . Hydrocarbon sources are contaminated with mercury at differing concentrations depending on regional geology (Carnell et al. 2014). Concentrations of mercury in the hydrocarbons removed at Camisea are not readily publically available (Pluspetrol 2009), However, through the exploitation and processing of the gas or crude there are several possible pathways that mercury could enter the environment. Flaring of gas or release of gas without flaring can release associated mercury to the atmosphere. Produce water containing mercury may escape treatment or containment and enter surface water and even that which is reinjected into the ground can escape and contaminate groundwater that can reach surface water. Additionally, improperly managed waste from the Malvinas processing plant that removes mercury may be a source of contamination. Appropriate studies to determine mercury pathways from the environment to the Nahua people and a review of the Camisea plant as a potential mercury source need to be conducted and where necessary measures taken to reduce exposure risk of the Nahua and control and eliminate the release of mercury into the environment.

Based on the reviewed materials and available information, we offer the following conclusions and recommendations.

Conclusions

It appears that a large segment of the sampled Nahua population in the village of Santa Rosa de Serjali is exposed to elevated levels of mercury however, the data available thus far are insufficient to fully characterize their exposure, the likely exposure pathways, and to determine the source(s) of the mercury contamination.

Recommendations (prioritized according to urgency)

1. Sample and analyze hair to determine the level of methylmercury exposure.
2. Sample and analyze a variety of major food items and fish sizes for total mercury from locations within, upstream and downstream of the village –
3. Based on fish concentrations measured thus far, consider advising children and pregnant and/or nursing women to avoid consuming large predatory fish (e.g., catfish or Mota spp.) from these waters.
4. Sample urine collected over a 24-hour period, using strict collection and storage protocols (available from WHO 2008).
5. Survey and measure surface soil for total mercury.
6. Monitor air in the village and upstream and downstream for total mercury.
7. Comparative studies with people living in neighboring areas (ie. upstream or in another basin, and downstream) as negative and positive reference sites
8. Review of mercury removal process and waste management at Malvinas plant, annual mercury loads to the airshed from flared gas, and potential fugitive produce water that may be carrying mercury to surface and groundwater at Camisea.
9. Whenever results are reported, confirm whether they are based on dry or wet sample analysis, require a description of laboratory methods, and ensure associated QA/QC data are provided.

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