Atmospheric mercury concentrations: when should we worry?

Pablo Higueros1,2*, Roberto Oyarzun2,3, José Maria Esbri1,2, Javier Lillo2,3, Alba Martinez Coronado1,2

1 Universidad de Castilla – La Mancha (Spain); 2 Instituto de Geología Aplicada (IGeA) - Universidad de Castilla-La Mancha, 3 Universidad Complutense de Madrid (Spain); * Universidad Rey Juan Carlos (Spain) * pablo.higueros@uclm.es

High concentrations of Hg\textsubscript{gas} are to be regarded for what they are, that is, localized phenomena that fade away in short distances. This is typical of mining districts where artisanal gold mining is practiced, although not many data from these sites get beyond a few hundreds ng Hg m\textsuperscript{-3}. However, the fact that high Hg\textsubscript{gas} concentrations are localized phenomena does not imply that they do not pose a danger 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, where concentrations may reach values in the order of 10\textsuperscript{3} - 10\textsuperscript{4} ng Hg m\textsuperscript{-3}. In this respect, while Hg\textsubscript{gas} can be truly regarded as a hazard, it is only under these localized conditions that becomes a clear risk for human beings.

Keywords: Gaseous atmospheric mercury, mining districts, tropical jungles, hazards, risks.

1 Cry wolf

We all know the story of the shepherd boy who repeatedly tricked nearby villagers by making them to believe that a wolf was attacking his flock of sheep. One day, when the wolf actually appeared in the scene, the villagers did not believe the cries for help and the flock was slaughtered. End of the story? Not long ago Ladle et al. (2004a,b) from Oxford University called the attention of the scientific community on the dangers of crying wolf. Although their letter to the journal Nature was on another controversial topic (climate change and mass extinction of biological species), the basic issue raised by these authors remains the same for a series of environmental issues. Ladle et al. (2004a,b) stated that "media coverage of conservation research is usually welcomed by the scientists involved, but there are pitfalls to heed.

Damaging simplifications of research findings may expose conservationists to accusations of crying wolf, and play directly into the hands of anti-environmentalists." In this regard, if we load the Google search engine with the words "mercury-danger", about 27,500,000 results turn up onto the screen (April-02-2015). This is a very relevant issue, because if anyone raises the alarm just because the instruments detect the existence of Hg\textsubscript{gas} we shall be doing a poor service to science and society in more than a way.

2 Toxicity, hazards, and risks

The World Health Organization (WHO, 2000) indicates that concentrations of Hg in air in the range of 15,000-30,000 ng m\textsuperscript{-3} may have effects on human physiology (tremors, renal tubular effects, change in plasma enzymes, and others). However, the same organization recognizes that these figures are rough estimates and that it seems appropriate to use an uncertainty factor of 20; thus, an estimated guideline for mercury concentration in air would be 1,000 ng m\textsuperscript{-3} (WHO, 2000). On the other hand, the US EPA (2012) indicates that a toxic substance is the one that can be harmful to the environment and to human health if inhaled, swallowed, or absorbed through the skin. The US EPA reference concentration for inhalation is calculated to be 0.0003 mg m\textsuperscript{-3} (300 ng m\textsuperscript{-3}) (time weighted average) (US OSHA, 2007). In addition to this definition the HESIS (2008) adds the amount (dose) of the substance that is required to cause harm.

The HESIS (2008) also indicates that the toxicity of a substance depends on its chemical structure, the extent to which the substance is absorbed by the body, and the body ability to detoxify the substance by elimination. Thus, the point is when and why should we get worried regarding a toxic substance. This is the key issue here because we may end up mixing the concepts of hazard and risk. While hazard is something with the potential to cause harm, risk is the likelihood that the harm will occur from exposure to the hazard. In this regard, a contaminant such as Hg\textsubscript{gas} is (no doubt) a hazard, although the big question is whether this contaminant may pose (or not) a risk to human health.

3 Artisanal gold mining in tropical areas: facts and fallacies

How all this relates alluvial gold mining and the use of mercury? Artisanal gold mining (AGM) in tropical settings has called the attention of many environmental groups for most of the last decades, which is partly because of the assumption that a “drop” of mercury can contaminate giant volumes of river water. However, mercury is only slightly soluble in water (e.g., WHO, 2005; Health Canada, 2009), in other words, the reaction Hg\textsubscript{0} = Hg\textsuperscript{2+} + 2e\textsuperscript{-} (E\textsuperscript{0} = +0.85) will be of lesser importance, particularly in organic-matter-rich, oxygen-poor waters as we may expect in some of jungle river waters such as those of Amazon basin, where oxidation of the abundant organic matter consumes O\textsubscript{2}
Artisanal gold mining and mercury: poverty and “real” risks

Whatever the case might be, the risks for the aquatic ecosystems and human populations will be mostly derived from the potential speciation of this element to methyl mercury and mercury gas. Another risk is provided by: 1) the accidental but usually common losses of Hg\textsubscript{metal}, and 2) the heating of Hg-Au amalgams to purify gold; given that mercury is very volatile, these processes result in either partial (1) or total (2) gasification of mercury (Hg\textsubscript{metal} → Hg\textsubscript{gas}). While both are of much concern, the second one directly affects to the miners performing the burning. Once mercury is in the lungs, the element is oxidized, thus forming Hg\textsuperscript{II} complexes that are soluble in the body fluids, which can induce permanent damage to the nervous system (Veiga et al., 2005). In this regard, whoever has inspected an AGM operation has been able to observe firsthand the precarious conditions in which the Hg-Au amalgam is dealt with.

Shanty towns characterize this landscape of misery inhabited by people that did not choose but somehow was forced to work under appalling conditions (Spiegel and Veiga, 2005). It is within this landscape where the most serious risks for human health are present. In this respect, the El Callao site in Venezuela (Veiga et al., 2005) (Figure 1) may be one of the many cases around the world in which we can properly cry wolf, as we are not addressing the ‘potentiality’ of a hazard to be become a risk, but of a case in which the people (miners and their families) are indeed facing a risk.

Figure 1.- Results from an atmospheric Hg survey at the El Callao gold mining site (SE Venezuela) during July 2008. This area hosts an important number of small-scale mining sites, as well as an important mine operated by the state-owned company Minerven. MRL: Minimum Risk Level (Higueras et al., 2014).

Acknowledgements

This work was supported by grants CGL2009-13171 from the Spanish Ministry of Economy and Competitiveness and PI1109-0142-4389 from the Castilla-La Mancha (Spain) Regional Government.

References


