

General Comments

Overall, the topic of this paper is an important public health issue in many parts of the World with small-scale gold mining. As written, however, this paper is very difficult to understand. I have given some examples below, although the entire manuscript needs to be critically reviewed for clear and concise English with appropriate word choices. The manuscript also appears to have a number of errors and a thorough review should be conducted of all citations and source information versus the information presented in the manuscript, as well as a thorough editorial review.

The nature of the presentation appears to be a narrative review. Although the paper describes the literature search methods, the inclusion and exclusion criteria appear to be few, and a critical review of study quality was not conducted.

More details and analysis would be helpful regarding the mercury levels at the various sites and media. No explanation is provided on whether appropriate analytical methods were used, detection limits, or whether water samples, for example, were total or dissolved. Generally, it appears that maximum values or single numbers are presented from different sites. This provides little perspective on the nature of levels in these areas.

Reported mercury concentrations in different media are compared to guideline levels (e.g., WHO, EPA); however, more explanation is needed of the basis of the guideline. For example, is the water limit given for drinking water (e.g., tap water) or for surface water which would include uptake and bioaccumulation in fish. Comparisons to site specific background levels would be helpful to understand the degree of elevation for each site.

Specific Comments. Comments are provided up to Line 263 because of time constraints. I apologize for any errors in my comments below. Time constraints limited efforts to recheck the comments.

More description of findings is needed in the executive summary.

Line 32. This sentence states that MeHg is the most dangerous form because it can bioaccumulate; however, it should be mentioned that discharges of other forms of mercury such as elemental can be transformed in aquatic sediments into MeHg. Use of elemental mercury in ASGM can also be hazardous because of inhalation of mercury vapor which readily crosses the blood-brain barrier and causes neurotoxicity.

Lines 52-53: "Hg has emitted over 2,220 (2,000–2,820) tons into the atmosphere (Figure 1)."

Revise this awkward and vague sentence to "over 2,220 (2,000-2,820) tons of Hg were released into the atmosphere from all anthropogenic sources in 2015." Clarification is needed to specify that this is total annual anthropogenic mercury not just from small-scale gold mining discussed in the previous sentences.

Lines 63-64: "A major problem is that mercury can regularly enter the local market."

I am not sure what is meant by “can regularly enter the local market.” Are the authors commenting that elemental mercury is readily available for use by individuals or is this sentence referring to environmental contamination?

Line 73 and Figure 2. Provide a source for the information presented on the locations of ASGM.

Lines 84-87: “Mercury is added to the pan to extract gold by forming a gold–mercury amalgam, which is squeezed through a cloth to remove liquid mercury, which remains without reacting with the gold.”

This sentence would benefit from additional explanation. It seems to say that the liquid mercury passes through the cloth, leaving gold behind, but the words “which remains” seems to imply that it stays in the cloth. The next sentence also indicates that additional processing (i.e., heat and vaporization) is needed to remove the mercury so not all of it passes through the cloth. Perhaps it should be stated that the “excess” liquid mercury that has not reacted with the gold is removed by the squeezing through a cloth, followed by heating to vaporize the remaining mercury amalgamated with the gold.

Line 92. It is unclear what is meant by “expert” labor. Is this referring to professional miners using best practices for health and safety and environment protection or is this referring to technical or highly educated workers?

Line 95. The six publications should be cited here.

Figure 3: the flow chart does not show the filtering through a cloth.

Lines 114-115. “According to article 7 of the convention, each party from ASGM shall develop a national action plan regarding Annex C.” Should this say “from countries with ASGM” rather than just from “ASGM”? It is not clear what Annex C is.

Line 119. The acronym “ASEAN” needs to be defined.

Table 1. The “Signature” column and the “Date” column both have dates. However, it is not immediately clear what these are referring to.

Lines 139-140. Two exclusion criteria for publications are noted: the date of publication and English language. How was date of publication used to exclude articles? Figure 5 also notes that some articles were excluded for “out of period”, but no dates are given for the inclusion period.

Line 159. Clarify that the gold processing area in Indonesia is an ASGM area.

Lines 164-166. What is the significance of site 1 versus site 2?

Line 168. “author” should be plural.

Lines 167-174. This paragraph appears to be discussing the findings of Murao et al. 2019 in the Philippines; however, the last two sentences seem unrelated. Specifically, estimated mercury emissions in Malaysia from ASGM are noted which is not reported in Murao et al., and the last sentence is a very general and unrelated statement: “The total mercury in the atmosphere can be determined by measuring the gaseous mercury.”

Lines 176-178. Highest concentrations from two surveys are presented in these two sentences. In both sentences, when providing a single value, it should be described as a “highest concentration” singular

not “highest concentrations” plural. Starting the second sentence with “Accordingly” is confusing. It appears that this is the second survey and this is what should be stated.

Lines 178-181. “These data were several times higher than the WHO guidelines of 1,000 ng/m³. As such, the study determined that Hg had been dispersed not only in the ASGM areas but also in its residents.” The words “As such” implies that the WHO guideline value indicates dispersion of mercury to residents. However, this would depend on how close residents were to the ASGM areas and meteorological conditions.

Lines 178-189. “Subsequently, Hg deposited in water bodies can be uptaken by aquatic organisms. Furthermore, inorganic mercury can be transformed into a toxic form biomagnified as MeHg.”

The content and order of these sentences implies that mercury is taken up by aquatic organisms which transform the inorganic mercury to MeHg. On the contrary, the methylation of elemental or inorganic mercury by bacteria in sediments should first be described with appropriate references. The resulting MeHg then biomagnifies in the food chain.

Line 191-192. Figure 4 which is called out here should be Figure 6. More information is needed on what the levels reported in Figure 6 represent. Are these means, maximums, etc.? Some representation of variability would be more descriptive. In addition, water bodies should be noted within countries, rather than just countries, since one location doesn’t represent an entire country. The source of these data should also be provided.

The order that countries are listed in this sentence is consistent with the order in Figure 6 but is not consistent with the subsequent presentation in the text.

Lines 195-196. “This study showed no correlation between Hg(0) and MeHg in river water, indicating that mining waste was not a direct source of MeHg in the Cikaniki River.” With the low variation in Hg water concentrations, surface water may not be as indicative of sources as Hg in sediment. Thus, the inference from the water concentrations may be inaccurate.

Lines 198-199. “Interestingly, the Hijo River in the Philippines supports food security and a means of living for local people who operate it for gold processing.” Use a different word than “operate” which implies that people are controlling the river.

Line 200. A more appropriate word than “dirty” water would be “effluent.”

Lines 201-202. Insufficient information is provided regarding these mercury water concentration values here and elsewhere in the article. When single concentrations are presented for each river, are these maximum concentrations or averages? Where were these measurements taken relative to the source of contamination?

Lines 207-208. What were the upstream and downstream concentrations? Wouldn’t the downstream values be higher than upstream if the site is the source?

Lines 209-212. “Though it is to take an example not from an ASGM area, another study from Malaysia collected sea and river water samples from Malaysia’s Port Dickson and Kuala Tereng-ganu in 2014 and determined that Hg concentrations ranged between 0.0016 and 0.0052 µg/L [21]. Compared with the other studies described above, the obtained values were relatively low.”

It is not clear why this other area is being compared to the ASGM areas. The beginning of the first sentence (Though it is to take an example not from an ASGM area) is also awkward and vague.

Lines 214-215. "Ayawaddy River, one of the main rivers in Myanmar, and groundwater from ASGM areas in the country, also feature concentrated Hg. The obtained data ranged from 0 to 0.04 µg/L."

Presenting a range that includes river and groundwater concentrations is not very informative. The low levels compared to other levels presented likewise seem to conflict with the statement that the rivers and groundwater "feature concentrated Hg". For example, the next paragraph presents the WHO guideline level of 0.5 µg/L.

Lines 214-221. As in other sections, lots of values are provided for mercury in groundwater here but without context on relevant background levels for these locations, it is difficult to comprehend the extent that Hg levels are elevated.

Lines 217-219. "The area closest to gold mining activities had a high potential for mercury contamination [22]. Samples obtained in the Ayeyarwady River, downstream of ASGM, recorded 0.005 µg/L Hg, and samples taken from the upper flow of the Ayeyarwady River contained 0.004 µg/L Hg."

I assume "upper flow" means upstream of the ASGM, but please state more clearly. The Hg concentrations presented do not much support the ASGM area as a source because upstream and downstream samples are low and very similar.

Lines 220-221. "The Hg concentrations of groundwater leaked from the ASGM mining tunnel..." Please describe this situation more clearly.

Lines 283-286 and elsewhere. Use consistent units throughout rather than switching between µg/g and ppm.

Lines 224-225. "ASGM areas in groundwater could affect mercury concentrations since Hg in groundwater can be derived from atmospheric sources [23]."

The meaning of "ASGM areas in groundwater" is unclear. More explanation is needed on how atmospheric sources can contaminate groundwater and why this explains how "ASGM areas in groundwater could affect mercury concentrations."

Lines 233-234. "The topsoil layer used to analyze Hg in soil decreases from the top layer to the bottom layer." The meaning of this sentence is unclear.

Lines 234-235. "Hg contamination of soils can be determined by its inclusion in fertilizers, lime, sludges, and manures." This sentence is difficult to understand and something may be missing.

Lines 235-237. "This study reviewed Hg levels in soils from Indonesia, the Philippines, Thailand, and Myanmar. Figure 5 shows the mercury concentrations in the soil from ASGM activities in Thailand, Myanmar, and the Philippines." Please clarify whether "this study" is referring to the previous citation or the current manuscript. It is unclear why Indonesia is not included in the countries presented in "Figure 5" since it is subsequently discussed and presented in the figure. Figure 5 should actually be Figure 7. The order of countries listed in this paragraph is also inconsistent with the subsequent discussion in the text and the order of countries in Figure 7.

Line 239. “The analytical Hg data showed 0–06.16.7 µg/g..” Please check this number.

Lines 246–247. This sentence states that the lowest concentration was 0.15 ug/g in the “nonmining area” “showing that Hg had contaminated the vicinity of the ASGM area.” However, without information on background levels, this conclusion is unclear. The other data presented in this sentence are of hot spots, so it is unclear what levels are “in the vicinity”.

Lines 248–250. “Likewise, a study of an ASGM operation in Thailand’s Phichit region considered surface soil (0–5 cm depth) from mining and nonmining areas. The observed data ranged between 0.016 and 10.56 µg/g.” How did concentrations compare between the mining and nonmining areas?

Lines 260–261. “Hg concentrations in soil do not typically exceed 0.1 µg/g, and average levels in soil were reported to be 0.05–0.08 µg/g.” Note whether this is worldwide or based on data from certain areas. Expected concentrations in soil for the various areas reviewed previously would provide useful context when presenting those data.

Lines 262–263. Reference 29 (M. Rajaei *et al.*, “Integrated Assessment of Artisanal and Small-Scale Gold Mining In Ghana—Part 2: Natural Sciences Review) is cited for the U.S. Environmental Protection Agency Guideline value of 0–0.2 ug/g. However, this reference does not seem appropriate. A U.S. EPA reference should be provided. Please also note the basis of this value. Is it for specific mercury forms, for residential or industrial land use, etc. U.S. EPA’s residential screening levels for various mercury compounds are higher than 0.2 ug/g.