Atmospheric Mercury Dispersion in Porto Velho City - RO, Amazon.

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Abstract: Although there was a significant reduction in gold mining activity in the Amazon in the recent years, Porto Velho, capital of Rondônia state, still has a total of five gold workshops in operation. It was possible, through this research, to evaluate the mercury concentration in superficial atmospheric sediment from streets (that is, dust), in which the average interval between the minimum and maximum values in the year 2003 was 109–1932 µg.kg⁻¹. Besides the environmental study, an occupational evaluation of the gold shop workers was carried out, as well as an evaluation of atmospheric air from inside the workshops. The mercury concentration in the atmospheric air inside the workshops did not exceed 0.0050 µg/m³. Concerning the occupational evaluation, the urine mercury concentrations were between 0.90 – 41.57 µg.L⁻¹, thus not exceeding the occupational limit of 50.00 µg.L⁻¹ (WHO).

Key word: Amazon, mercury, atmospheric, occupational

INTRODUCTION

Elementary mercury vapour is possibly oxidized in the atmosphere through catalytic reaction with O₃ and solar energy. The ionic species Hg²⁺ is removed from the atmosphere by pluvial waters and precipitated in aquatic and terrestrial environments where it is potentially reactive, and may be transformed to organic species which are capable of being assimilated by biota (LINDQVIST ET AL., 1984).

In the Amazon, many study results indicate the presence of mercury in rivers, forests, in fish and consequently in the human population. In atmospheric air, high concentrations of mercury were found near smelting operations in gold mining activity and in gold workshops in Amazonian cities (PFEIFFER ET AL., 1992).

In Rondônia, gold mining activity started in 1978, increasing until 1985, when it started to reduce (MALM, 1991).

Nowadays, with the reduction of gold mining activity, the number of gold workshops in Porto Velho has also diminished (Figure 1). Those gold shops are the main source of mercury vapour in the region, for they perform the final ignition of the gold-mercury mixture.

Through the monitoring that has been carried out in the Amazon region it is possible to map the dispersion of metallic mercury vapour in the commercial area of Porto Velho.
MATeRIAl AnD MeThoDS

The collection of superficial atmospheric sediment in the streets (that is, dust) was made in a one year period at 10 sampling points near gold workshops in Porto Velho, between the dry and wet period. The samples were stored in plastic bags and subjected to a sieving process for particle selection (<200 mesh) in the laboratory.

The atmospheric air samples were collected by a bubbler system with controlled flowrate containing an oxidant solution (KMnO\textsubscript{4} + H\textsubscript{2}SO\textsubscript{4}) (Figure 2). This system was operated inside the gold workshops for two hours.

In the occupational evaluation, 20 urine samples from 10 gold workshop workers were collected at the beginning and end of each day’s travel to work, by the distribu-

**Figure 1.** Area of study in Porto Velho.

**Figure 2.** System of air collection inside the gold workshops.
tion of polyethylene bottles to each worker. At the same time, informed consent of the participants was given.

For the determination of mercury concentration, the samples underwent chemical digestion with subsequent analysis by atomic absorption spectrophotometry coupled to cold vapour generation (FIMS-400 da Perkin Elmer). The analytical methodology used here was based on the techniques developed by Bastos et al. (1998).

**RESULTS AND DISCUSSION**

The sampling points of superficial atmospheric sediment in the streets showed smaller mercury concentrations in the wet period between October and January where the minimum value was 109 μg.kg⁻¹ in January and a maximum value of 1163 μg.kg⁻¹ in October (Figure 3). The months from May through September that represent the dry period showed averages between 1526.64 – 1932.03 μg.kg⁻¹.

![Figure 3. Mercury concentration distribution in superficial atmospheric sediment throughout the months of 2003.](image)

All the street dust collection points showed high levels of mercury; moreover, the variability was high between the sampling points and with time in 2003.

The atmospheric evaluation inside the five gold workshops in the commercial area of Porto Velho was carried out using the air bubbler system (Table 1).

The mercury concentration found in the workshops was low and the highest value found in the two collection periods was 0.0050 μg/m³ of mercury.

In the occupational evaluation through urine samples the values of mercury ranged from 0.90 to 41.57 μg.L⁻¹, without exceeding the limit value recommended by WHO of 50.00 μg.L⁻¹ (Table 2).
Table 1. Total mercury concentration in atmospheric air inside gold workshops in Porto Velho-RO.

<table>
<thead>
<tr>
<th>Gold Shops</th>
<th>[Hg] (μg/m³) Dry Season 2002</th>
<th>[Hg] (μg/m³) Dry Season 2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.0050</td>
<td>0.0040</td>
</tr>
<tr>
<td>B</td>
<td>0.0010</td>
<td>0.0001</td>
</tr>
<tr>
<td>C</td>
<td>0.0001</td>
<td>0.0001</td>
</tr>
<tr>
<td>D</td>
<td>0.0001</td>
<td>0.0010</td>
</tr>
<tr>
<td>E</td>
<td>0.0030</td>
<td>-----</td>
</tr>
</tbody>
</table>

Table 2. Average Hg concentration in the urine of gold workshop workers before and after work in Porto Velho, 2002/2003.

<table>
<thead>
<tr>
<th>B.D.J. (μg.L⁻¹)</th>
<th>S.D.</th>
<th>Min.</th>
<th>Max.</th>
<th>E.D.J. (μg.L⁻¹)</th>
<th>S.D.</th>
<th>Min.</th>
<th>Max.</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.51</td>
<td>12.07</td>
<td>1.84</td>
<td>41.50</td>
<td>11.43</td>
<td>8.15</td>
<td>0.90</td>
<td>29.42</td>
<td>10</td>
</tr>
</tbody>
</table>

B.D.J.: Beginning of day’s journey  
E.D.J.: End of day’s journey.

CONCLUSIONS

In the superficial atmospheric sediment from the streets 70.83 % of samples showed values above the average mercury content of Amazon region soils (100-200 μg.kg⁻¹). The dry period (May – September) showed the highest concentration, especially due to the presence of gold mining activity during the dry period. This, consequently, increases the combustion activities in the gold workshops. The low values found in the atmosphere inside the workshops are a result of the use of hoods, thus reducing the Hg vapour concentrations inside the shops and releasing it into the open air, outside the shops. In the occupational evaluation none of values found exceeded the WHO values.

Acknowledgements

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Solutions for Mercury Pollution in Artisanal Gold Mining in the Kadoma-Chakari area, Zimbabwe

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Abstract: The broad objectives of the current study within the framework of the GEF/UNDP/UNIDO Global Mercury Project are to assess the extent of mercury use and the resultant pollution and to mitigate the effects of mercury pollution through training, awareness campaigns and the transfer of cleaner technology to workers. Artisanal gold mining in the Kadoma-Chakari area involves as many as 30,000 miners, millers and panners. About 3 to 5 tonnes of mercury is released into the environment annually. The project is implementing a Transportable Demonstration Unit to educate miners on the impacts of mercury as well as to improve their gold recovery methods.

Key words: artisanal gold mining, gold amalgamation, Zimbabwe, Kadoma-Chakari

MINERAL PROCESSING AND THE USE OF MERCURY

It is estimated that there are between 300,000 and 400,000 artisanal and small-scale gold miners (ASM) producing, according to official statistics, 5 tonnes/a of gold and sustaining the livelihood of at least 2 million people in Zimbabwe (MAPONGA AND NGORIMA, 2003; VAN STRAATEN, 2000). About 20,000 to 30,000 people are directly involved in gold extraction in the Kadoma-Chakari region. There are three categories of people in the area: miners (about 3,000 to 5,000 people) who excavate the ore in legal concessions and take this for processing at custom milling centers; millers (1,000 to 2,000 people within 70 milling sites) who process the ore, and panners (15,000 to 25,000 people) who usually are not locals and illegally extract gold (0.2 to 0.4 g Au/panner) by panning gravels in creeks and rivers; they are frequently harassed by the local police. About 20 tonnes/a of Hg are imported from the Netherlands for industrial and dental use but a large part is diverted to ASM. Based on field observations, it is estimated that Hg losses in the region alone must be between 3 to 5 tonnes/a.

Mineral processing at custom milling centers in the Kadoma-Chakari area involve grinding, concentration, amalgamation and cyanidation. Milling facilities are very well set up and the techniques are very adequate for the custom-milling scheme. For crushing and grinding, some centers use wet stamp mills (3 or 5 stamps) with capacity of 0.2 to 0.5 tonnes/h and some use jaw crushers followed by grinding with ball mills (capacity of 0.7 to 2 tonnes/h). The centers charge Z$