

# MERCURY POLLUTION CAUSED BY ARTISANAL GOLD MINING IN THE OCOÑA RIVER VALLEY, PERÚ

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## Introduction

In the Ocoña river basin several artisanal mining settlements occur. this valley is located in the Arequipa department, South of Perú (Fig. 1). The main deposits are Posco-Misky, San Cristóbal, Carro Rico and San Juan de Churunga.

This is a gold mining activity. In most of these mining settlements, miners work taking in advance old mines that have previously been used by mining enterprises and what they leave because low profitability. In these places gold grades are high up to 60 g/t, but gold is found in narrow veins (Fig. 2), and then, reserves are small.

The recovering of gold in these mining activities is performed as an amalgam with mercury. Gold-containing mineral is grinded using mills, in Peru called "quimbaletes" (Fig. 3) together with mercury. The gold-mercury amalgam is recovered directly using the hands without protection (Fig. 4).

Finally amalgam is burned for obtaining pure gold. In some places quimbaletes are located outside the place of residence as in Posco-Misky, where they have a special place 5 km far from the population, called San Martín, where quimbaletes work daily, where each processes 30 kg / day of material, with a consumption of kg of mercury, 20% of the mercury that is not recovered is deposited into the environment. According to Nriagu (1994), between 60-65% of mercury is deposited in the atmosphere creating serious environmental pollution.

The present study aims to evaluate the pollution of mercury used to gold recovering in the Ocoña river valley.

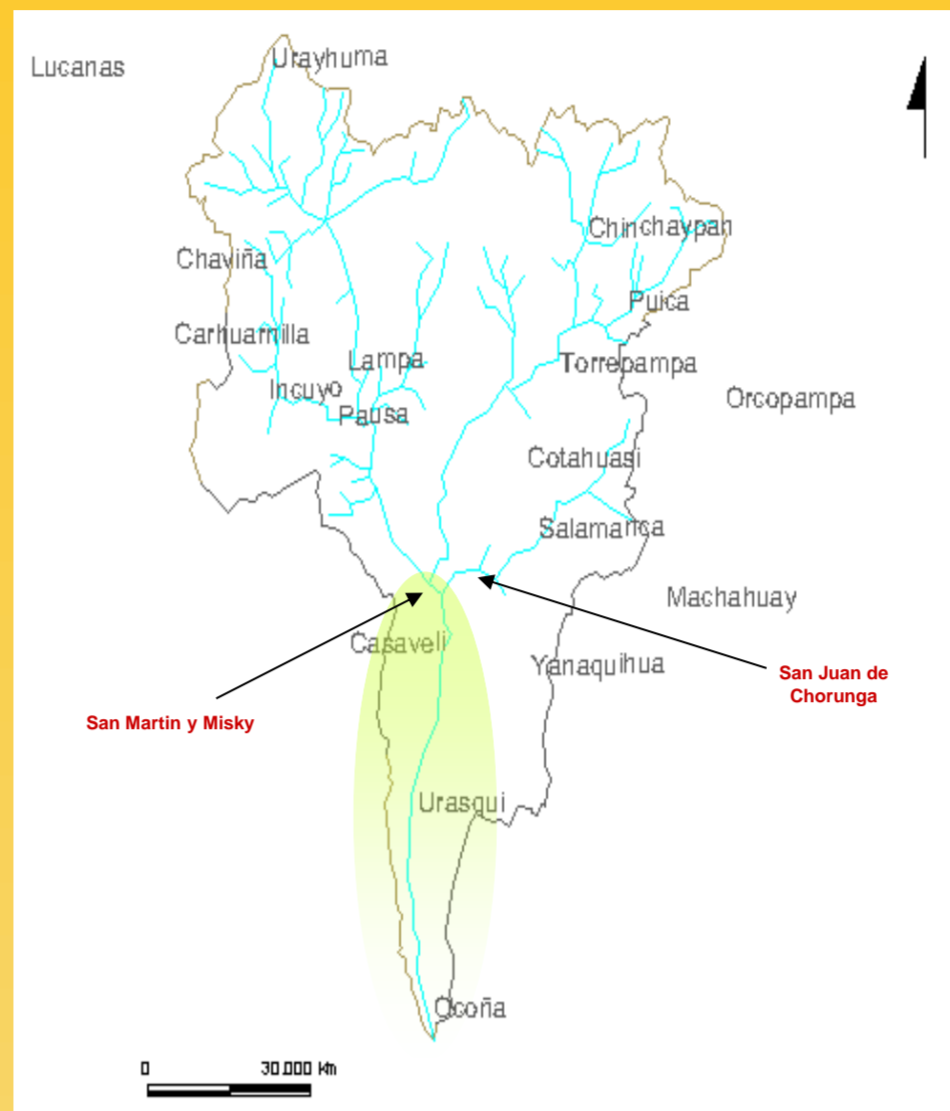


Fig. 1. Location of Ocoña river Basin.



Fig. 2. Quartz vein with sulfides

## Methodology

For the environmental assessment of the area contaminated by mercury, we proceeded to the taking of samples of different types: water, rocks, plants and hair.

It has produced a map with the different areas sampled as representative as possible and appropriate access for making results. Obtained a total of 12 samples of water, 3 plants, soil 3 and 20 samples of hair.

In the analysis method used to plant, soil, and hair was atomic absorption spectrometry for determination of total mercury.

Statistical analysis using the Minitab program, which analyzed the standard statistical variables. Further correlation test is performed between different variables.



Fig. 3. Processing with quimbaletes



Fig.4. Mercury amalgam.

## Results and discussion

Different analyzes were conducted in two universities: Universitat Politècnica de Catalunya (Manresa) and the University of Castilla la Mancha (Almadén). Its purpose is to measure the concentration of mercury in different media.

In total 12 samples were analyzed for water, where there is a very high mercury concentrations in the first three samples, with values greater than 1 mg / l, high values in the samples and low values  $\bar{N}$ -4/5/6 the remaining samples (Table 1). The pH varied between 7.03 and 8.73, therefore considered that the water is acidic. Water temperatures are between 16.2 to 22.8 °C. The climate of the area is mountainous, cold at night and hot during the day, so the water temperatures can reach different values, depending on the time of day of sampling.

According to the World Health Organization, the maximum allowable limit for drinking water is 1 g/l. Sampled water is not used for human consumption, but for personal hygiene, laundry or clean kitchen utensils. It is also used for consumption of animals. By analyzing data on hair, the concentration range of total mercury is 0.62  $\mu$ g/g - 6.43  $\mu$ g/g, with an average of 2.78  $\mu$ g/g. According to occupations, people that works in quimbaletes has the higher values obtained 4,141  $\mu$ g/g, followed by students 1.98  $\mu$ g/g, 1.85  $\mu$ g/g mercury vendors / g, vendors sometimes quimbaletes mercury and 1.66  $\mu$ g/g, cooks 0.83 mg / g babies finally 0.72  $\mu$ g/g. As for gender, women get higher values than in the case of males, 2.95 mg / g and 2.64 mg / g respectively. The 89.5% of the population, exceed the total mercury dose according to WHO (World Health Organization), as the value set is 1  $\mu$ g/g. Only two out of 19 samples have values below this threshold (Table 2).

The population of Almadén, southern Spain where the mercury mines located, are required hair mercury amounts varying from 0.20 to 9.35  $\mu$ g / g, with an average of 2,64  $\mu$ g/g (Esbrí et al., 2012). According to other studies, where artisanal mining works by extracting gold with mercury in Venezuela, extremely higher values are observed, with an average of 6.1  $\mu$ g / g, (Alvarez and Rojas, 2006).

Three types of plant were analyzed and their corresponding sediments. It is worth mentioning that the number of plants analyzed is much less than ideal, since the study area is desert, and it is very difficult to find a variety of them. In general, the concentration of Hg in plants values were low (V2planta = 0.427 mg/g V3planta = 0.952) and a high value of 7.17 in the V1 mg/g, plant located near the processing area and use of mercury. Mercury concentrations in sediments are varied (V1sed = 62.5 mg/g, V2sed = 0.427 mg/g V3sed = 0.186 mg/g).

According to this study, children have a high content of total mercury in hair, with average values of 1,983  $\mu$ g/g. The nearest areas where processes are performed amalgamation, there are higher concentrations of mercury in water.

Alternative methods are being studied gold recovering without the use of mercury, such as bioleaching.

Table 1. Hg content of water samples from the Ocoña subbasin.

|      | Hg Dissolved mg/l | Hg Total mg/l | pH   | Temp. °C |
|------|-------------------|---------------|------|----------|
| Ñ 1  | 34,20             | 61,10         | 7,71 | 18,4     |
| Ñ 2  | 20,50             | 27,20         | 7,69 | 17,3     |
| Ñ 3  | 0,20              | 1,20          | 7,97 | 17,5     |
| Ñ 4  | 0,50              | 0,90          | 7,30 | 17,7     |
| Ñ 5  | 0,30              | 0,80          | 8,73 | 19,7     |
| Ñ 6  | 0,20              | 0,70          | 7,03 | 18       |
| Ñ 7  | 0,10              | 0,40          | 7,63 | 16,8     |
| Ñ 8  | 0,02              | 0,07          | 8,18 | 21,7     |
| Ñ 9  | 0,01              | 0,01          | 8,18 | 21,2     |
| Ñ 10 | 0,01              | 0,01          | 8,34 | 19,6     |
| Ñ 11 | 0,01              | 0,01          | 8,13 | 20,5     |
| Ñ 12 | 0,02              | 0,02          | 8,12 | 22,2     |

Table 2. Concentration of Hg in hair in people from Misky.

| Sample | Concentration Hg (mg/Kg) | Age | Sex    | Occupation    | Amalgama | Consumption fish |
|--------|--------------------------|-----|--------|---------------|----------|------------------|
| C-1    | -                        | 25  | male   | Quimbalete    | no       | 1 time/month     |
| C-2    | 3,66                     | 24  | male   | Quimbalete    | no       | no               |
| C-3    | 4,24                     | 50  | male   | Quimbalete    | no       | 1 time/day       |
| C-4    | 2,08                     | 17  | male   | r             | no       | 1 time/month     |
| C-5    | 2,31                     | 19  | male   | Quimbalete    | no       | 1 time/month     |
| C-6    | 1,85                     | 33  | female | Hg seller     | no       | 1 time/week      |
| C-7    | 4,78                     | 27  | male   | Quimbalete    | Yes      | 3 timonth/month  |
| C-8    | 1,97                     | 37  | female | Seller/Quimba | No       | 2 timonth/week   |
| C-9    | 0,62                     | 44  | female | cooker        | No       | 3 timonth/month  |
| C-10   | 2,88                     | 38  | female |               | Yes      | 3 timonth/month  |
| C-11   | 1,47                     | 4   | male   | student       | No       | 4 timonth/month  |
| C-12   | 6,43                     | 28  | female | Quimbalete    | No       | 4 timonth/month  |
| C-13   | 1,35                     | 24  | female | Seller/Quimba | yes      | no               |
| C-14   | 4,14                     | 63  | male   | Quimbalete    | no       | 4 timonth/month  |
| C-15   | 0,71                     | 0,6 | male   |               | no       | no               |
| C-16   | 1,8                      | 4   | female | student       | no       | 4 timonth/month  |
| C-17   | 1,04                     | 39  | male   | cooker        | no       | 4 timonth/month  |
| C-18   | 2,12                     | 6   | male   | student       | no       | 4 timonth/month  |
| C-19   | 2,54                     | 10  | male   | student       | no       | 4 timonth/month  |
| C-20   | 6,75                     | 40  | female | Quimbalete    | no       | no               |

## Conclusions

The nearest areas where processes are performed amalgamation, there are higher concentrations of mercury in water. The plants and soil also processes closest to contain mercury higher values.

According to the means by occupation, students (children 3 to 16 years), have a high content of total mercury in hair, with average values of 1,983  $\mu$ g / g. The nearest areas where processes are performed amalgamation, there are higher concentrations of mercury in water.

It provides a continuation in environmental studies, in order to obtain results on the effects that the use of mercury or other chemicals for the production of metal. They study the possible remediation and seek other methods for obtaining gold, less corrosive and harmful to people and the environment.

## References

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