Environmental pollution produced by gold artisanal mining in the Mapiri river basin, Apolobamba, Bolivia

K.S. Villegas[(1)], P. Alfonso[(2)], P. Higueras[(3)], S. Palacios[(2)], J.M. Esbrí[(3)], E.M. García-Noguero[(3)]

(1) Escuela de Postgrado, Universidad Técnica de Oruro, Oruro, Bolivia.,
(2) Dept. Enginyeria Minera i Recursos Naturls, Universitat Politècnica de Catalunya, Manresa, Spain
(3) Instituto de Geología Aplicada, Universidad de Castilla-La Mancha, Almadén, Spain

Introduction

Mining activity is very important in Bolivia since colonial times. Nowdays it has been reactivated, especially gold mining, due to rise in metal prices.

Artisanal and small-scale mining activities are abundant in the protected area of Apolobamba, department of La Paz; it is located near the border with Peru. Several rivers occur in this area, The most important are the river Suches, in the border with Peru, that drain to the Titicaca Lake and the Mapiri river, that is afluent to the Amazonas river.

In the northern part of this area gold is mined from veins. Here mercury is used to recovery gold by obtaining an Hg-Au amalgam. This manipulation with mercury causes an important environmental impact in the area. otherwise, in the south part of the Mapiri basin gold is in placer-type deposits and it is obtained by mechanical techniques without the use of mercury.

The present work is a preliminary study of the contamination of the Mapiri river basin in the Apolobamba area, which drain into the Amazonas river. The present study also aims to do a preliminary evaluation of the efectivity in gold recovery of the amalgamation method in this area.

In the head of this basin, located at more than 4000 m above sea level. According to Hentschel et al (1999) about 15 tones of Hg are discharged in the environment in Bolivia every year.

Another additional problem to the use of mercury to gold recovery is the price that is increasing a very high rates due to the low production of mercury due to the European Comunity phobitition to produce it for its members.

Geology

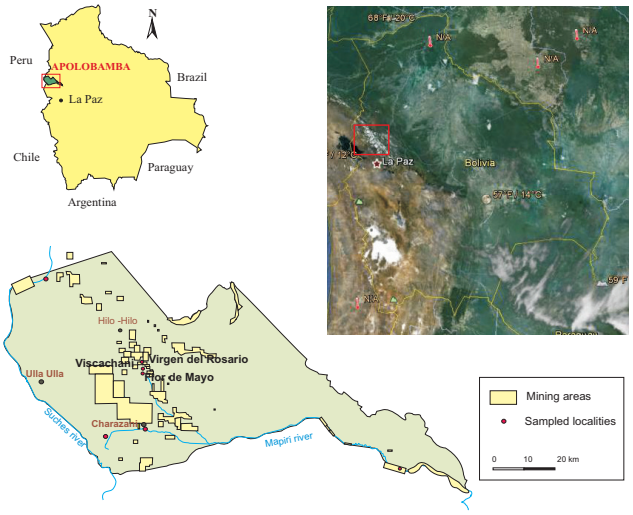
In the Apolobamba protected area gold occurs as primary and secondary deposits. In the northern part of the Mapiri river basin gold occurs in hydrothermal quartz veins of Paleozoic age. The area is abundantly covered by quaternary sediments. In other cases as in theSuches river and in the southern part of the Mapiri river basin, gold occurs in placer-type deposits, where it is free, but it occurs in very small particles.

Veins, that constitute the primary gold deposits, are hosted in metasedimentary rocks, mainly shales and schists. Quartz veins often also contain sulphides as pyrite, sphalerite, galena,arsenopyrite, chalcopyrite and sulphosalts and telurides.

Sampling

We have sampled several mining sites from this area, in particular the ones known as Viscachani, Virgen del Rosario, Flor de Mayo and Chojlaya, located in the proximity of the head area of the Mapiri river and the head of the Tuichi river. Also the exploitations in the proximity of the locality of Mapiri, in the south of the aplolobamba were sampled.

All these mining sites were in activity during the present sampling campaign.The processing of gold takes place near the mines, where the mines also live.



Maps of the protected area of Apolobamba with the location of the studied artisanal mining activities.

Analytical methods

The content of several metals were measured by means of XRF (Se, As, Cu, Zn, Cd, Pb, Hg) in tailing samples from the different gold mining sites in the ACTLABS laboratory.

In addition mercury concentrations in water and in vegetation close to the processing areas were determined by means of atomic absorption spectrometry with Zeeman effect (LUMEX RA-915 Equipment) in the Universidad castilla-La Mancha.

The concentration of mercury also was determined in the air along the study area with a portable LUMEX RA-915 Equipment.

Extraction of gold by amalgamation with mercury at Flor de Mayo.

View of the large tailings of the Flor de Mayomining activity.

Extraction of gold by amalgamation with mercury at Viscachani. Mercury is mixed with the mineral in ball mills where it is pulverized and gold forms an amalgam with mercury.

After the extraction of gold by amalgamation with mercury, tailings still are rich in gold. Many women of the area work to recover gold from them.

Results

Tailings are mainly constituted by quartz with minor contents of clay minerals and sulphides. Gold content, after recovery with mercury, is high, between 4.56 ppm and 10.35 ppm (Table 1).

The Hg content of the tailings ranges from 149 to 1027 ppm. Here, lixiviable mercury ranges between 30.10 and 859.94 ng/l. Water released from the tailings contains between 0.1 and 5.7 ppb of Hg.

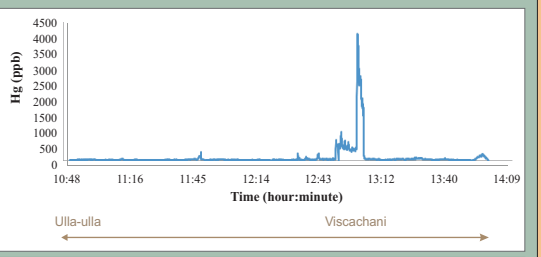
The analysed vegetation, which is typical of the area, has high Hg contents, from 162 to 219 ppm.

The measurement of the Hg content in the air is negligible except close the mining activities, where it can reach up to high values (eg. 4.4 ppm in Viscachani).

In addition there is a high arsenic content in all the studied tailings, except in those from the Viscachani mining site, where concentrations of this element ranges from 456 ppm to 18540 ppm. The Pb content usually ranges from 337 to 939 ppm. The Chojlaya mining site tailing has exceptionally high values of heavy metals: Pb content is between 2.26 and 3.27 wt.%, Cd ranges from 160 to 228 ppm, Zn from 194 to 794 ppm, Cu from 847 to 1052 ppm and Se from 105 to 187 ppm (Table 2). These contents also contribute to an environmental pollution.

Table 1. Content in Au, Hg and As of tailings from the Apolobamba potected area.

Sample	Location	Au ppm	Hg ppm	As ppm
M1	Tailing head Tuichi	1.75	75	1790
M2	Tailing head Mapiri	8.40	122	20
M3	Tailing head Mapiri	9.88	364	13462
M5	Tailing lower Mapiri	0.02	2	28
M6	Tailing lower Mapiri	4.56	-	-
M7	Tailing lower Mapiri	7.50	-	-
M8	Tailing lower Mapiri	10.35	-	-
M10	Tailing lower Mapiri	0.04	-	-



Graphic of the measurement in situ with the LUMEX portatil spectrometer, of the Hg content in the air along the road from Ulla Ulla to Viscachani.

Table 2. Content (ppm) in different metals of tailings and veins from the Apolobamba potected area.

Sample	Location	Type	Cr	Ni	Cu	Zn	As	Se	Mo	Cd	Hg	Pb
P 3	Viscachani	Tailing	0	0	17	50	22	21	18	5	210	302
Q 1'	Flor de Mayo	Tailing	87	23	36	475	18540	0	17	39	255	939
Q 4	Flor de Mayo	Tailing	28	0	2	99	4388	0	16	19	149	337
R 4	Chojlaya	Tailing	192	45	1052	194	456	187	8	228	232	32704
R 5	Chojlaya	Tailing	103	30	847	794	1000	105	26	160	1027	22627
R 12	Chojlaya	Vein gouge	537	38	5001	498	613	163	34	207	4	29999
R 6-3	Chojlaya	Vein gouge	318	0	0	38	0	49	28	0	0	4138
R 13	Chojlaya	Vein	231	10	11	100	7	28	35	39	0	234
R 14	Chojlaya	Vein	258	21	35	141	16	25	34	48	0	396
R 6.1	Chojlaya	Selected mineral	2120	636	684	781	19298	757	59	6387	388	291837

Discussion and Conclusions

The artisanal gold mining activities in the northern part of the Mapiri river basin use mercury to the gold recovery processment. They led to an intense environmental pollution, mainly related to mercury and arsenic contents. Mercury pollution is due to the use of this element to do an amalgame with gold as a recovery tecnique.

Tailings from Chojlaya also are rich in heavy metals as Pb, Cu, Cd and Se. These contents produce contamination of soils and water.

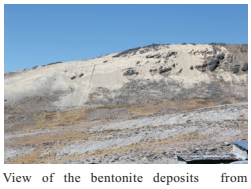
Vegetation of the area is very effective in capturing Hg, then it could be used as a fitoremediation system to reduce the contamination of mercury in the water courses of the area. In addition, in the surroundings of Viscachani large deposits of bentonite occur. These clays could also be used to reduce the Hg and As pollution in water by making barriers .

As content is important in several mine sites. Arsenic come from the destruction of arsenapyrite, wich is present as an abundant mineral in many locations of mining activity. In addition to the environmental contamination caused by this component, the content of As makes difficult the amalgamation of gold and mercury; in these cases more mercury is necessary to added to obtain the amalgamation and gold recovery. Then, in these cases the use of mercury is specially non effective in gold recovering.

After processing, tailings still contain important amounts of gold suggesting that the amalgamation method is not effective to gold recovering. In some places silver sulphosalts are abundant, then Ag could be in ecomomic contents. The Ag content should be investigated and took into account when exploitation.

More research should be done to quantify other possible metals that could be of economic interest, as silver. In addition, an alternative method to the use of mercury should investigated to be used torecovery gold in these exploitations, according to the sustainability concept.

Typical vegetation of the area which absorbs important contents of Hg.



View of the bentonite deposits from Viscachany.

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Acknowledgements

This research was financed by the project AECID: A3/042750/11 and the Consolidated Group for Research of Mineral Resources, 2009SGR-00444.