UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

VIENNA INTERNATIONAL CENTRE, D1278, P.O. BOX 300, A-1400 VIENNA, AUSTRIA

Mercury Pollution from Artisanal Gold Mining in Block B, El Callao, Bolivar State, Venezuela: Health and Technological Assessment

(Project XP/VEN/03/C04)

May 2004

United Nations Industrial Development Organization
Vienna, 2004

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EXECUTIVE SUMMARY

The technical and health aspects of the gold mining activity conducted by artisanal and small-scale miners in the Block B, El Callao, Bolivar State, Venezuela, were evaluated. The population of Block B is estimated to be around 1730 people, with about 30% of children with age below 15 and the large majority of the adults directly involved in mining. About 1/5 of the population is illiterate and 1/4 does not have any kind of technical education. The area is a legal mining concession of CVG-Minerven rented to small-scale mining individuals/companies. Miners extract the ore from 30-80 m deep shafts using explosives and transport it in small trucks to the Processing Centers (locally known as "molinos") to be crushed, ground, concentrated and amalgamated. Based on the average gold production, **the Block B production might be around 1 to 2 tonnes Au/a** considering that there are 28 active Processing Centers in the area. In all El Callao, the gold production can reach as much as 5 to 6 tonnes/a considering that there are 80 to 90 Processing Centers in all region.

By using copper-amalgamating plates to amalgamate the whole ground ore, large amount of mercury is lost with the tailings. The amalgam recovered from the plate is burned on a tray or a shovel. Some millers have good retorts available for miners but the miners insist that the retorting time is too long (15 minutes) and they simply use a propane blowtorch to decompose amalgam, emitting large amount of mercury to the atmosphere and exposing themselves to mercury vapor. This is clearly contaminating everyone directly involved in the ore processing as well as their neighbors, since the Processing Centers are very near the houses. The ratio Hg_{lost}: $Au_{produced}$ is around 1.5 to 2. **The mercury emission in Block B is estimated to be between 2 and 4 tonnes/a**. **In all El Callao, the mercury emission can reach as much as 12 tonnes/a**.

The levels of **mercury intoxication** of the gold miners and millers working in the Block B, El Callao, Venezuela, is one of the **most serious in the world**. Signs of serious intoxication and neurological damages were detected in a large majority of those directly involved in the amalgamation process as well as in innocent people living near the Processing Centers. The use of rudimentary copper-amalgamation plates associated with burning amalgam on shovels is exposing workers and surrounding communities to high levels of mercury vapor.

A total of 165 volunteers were interviewed using UNIDO's Protocols and 105 persons were selected to perform neurophysiological tests. A total of 209 samples of urine (66 samples from women, 62 from children, 48 from millers and 33 from miners) were collected and analyzed for Hg and creatinine using a portable atomic absorption spectrometer LUMEX. The overall average of total Hg concentration in urine, was 104.59 µg Hg/g creatinine with standard deviation of 378.41 µg Hg/g creatinine. About 61.7% of the sampled individuals have Hg levels in urine above the ***alert*** level of 5 µg/g creatinine, 38.3% of the individuals have Hg levels above the ***action*** level (20 µg/g creatinine), 20.6% above the ***maximum*** of 50 µg/g creatinine recommended by the World Health Organization and 15% above 100 µg/g creatinine which is the level where neurological symptoms are very likely. The situation with miners and millers is dramatic as 30% and 79% of the miners and millers respectively have Hg in urine above the ***action*** level and 52% of the millers have levels above 100 µg/g creatinine. In addition, about 14.6% of millers have shown extremely high mercury concentrations in urine, ranging from 1221 to 3260 µg Hg/g creatinine. This result allows the generalization that **more than 90% of the sampled individuals working in the Processing Centers (millers) have Hg levels in urine above the *alert* level.** Symptoms typically associated with chronic exposure at very high levels of mercury, acute intoxication, long term exposure at low levels of mercury vapors and long term exposure at high levels of mercury vapors (e.g. muscular tremor) were identified in Block B workers and residents.

As a result of indirect exposure of mercury vapors, it was observed that about 27% of the women have Hg concentration in urine above the ***alert*** level and 21% above the ***action*** level. About 53% of the 62 children sampled have Hg concentration in urine above the ***alert*** level and 14.5% above the ***action*** level. **Almost 10% of the sampled children have levels of mercury in urine above 100 µg/g creatinine**. Mercury concentration as high as 320 µg Hg/g creatinine was analyzed in a 7 year-old boy. In Monkey Town, 25 % of the urine samples from children have Hg concentrations above the ***action*** level, and the maximum Hg concentration was found in the urine of a 13 year-old girl (384 µg Hg / g creatinine).

The neurological signs of mercury intoxication found in women, children, miners and millers were ataxia, trembling of the hands, trembling of eyes, incapability of performing the finger-nose test, dysdiadochokinesia, patellar and hyper-reflexia, and patellar and cubital hypo-reflexia. In 25% of women and children and 28% of the miners and millers, it was possible to identify some of these symptoms.

When correlating the neuropsychological tests with levels of Hg in urine, it was possible to notice that individuals with high mercury concentrations in urine (above 50 µg Hg/g creatinine) have shown difficulties to complete the WMS-Memory Test. Similar situation was observed in the Finger-Tapping Test. The Episodic Memory Test (Mini-Mental) was very useful to show the % of individuals with no problem to perform the test decreases when the Hg level in urine increases. The % of individuals with poor performance in this simple perception-memory test increases with the level of Hg in urine. About 27% of individuals who performed the specific neuropsychological tests have noticeable neurological problems detected in the clinical exams.

Analytical techniques were discussed and transferred to the laboratory of the La Salle Foundation in San Felix, Ciudad Guayana. The methodologies for quantitative and semi-quantitative analyses (colorimetric method) of total mercury were demonstrated to the technicians and reagents were left for them.

This work did not attempted to assess the environmental problems caused by mercury use in the Block B. However it is clear that the runoff waters coming from the Processing Centers raises environmental concerns as mercury is being carried to the main drainages either associated with particulate matter or solubilized as Hg-organic complexes. Fortunately the local streams do not support intense fishery and the local population does not have fish as part of its main diet.

The amalgamation of the whole ore after grinding the ore at -1mm is resulting in tailings with 60 to 80 mg/kg of mercury. These tailings are being poorly disposed in ponds, which have contact with the local drainage. The environmental effect of this is still unknown. CVG-Minerven, a State owned company and other organized mining companies periodically purchase these tailings to be processed in their cyanidation plants. This is transferring the mercury pollution to the companies' environment, contaminating both employees and tailing dams.

The use of simple pieces of equipment such as sluice boxes with carpets or with a novel type of magnetic liner (Cleangold®) was demonstrated to the miners and millers. Four tests using more than 1 tonne of Hg-contaminated tailings were conducted. The tests used four-special-amalgamating Goldtech plates that removed up to 95% of the mercury from tailings. Cleangold sluice box obtained a concentrate with 2854 mg/kg of Au. Very fine gold was recovered with this simple equipment. By combining Cleangold sluices and Goldtech plates (arranged in zigzag), it was possible to recover 15.4% of gold from tailings. These simple techniques can reduce mercury emissions and increase gold recovery.

All results have reinforced the conclusion that lack of gold liberation is the main problem in increasing gold production in El Callao. The use of hammer mills to re-grind tailing samples does not bring any benefit in terms of increasing gold liberation. This is the main reason for gold loss in the Processing Centers and high recovery in the CVG-Minerven cyanidation plant, since the mining company uses ball mills to re-grind the tailings at least below 200 mesh (0.074 mm).

The only possibility to increase gold recovery in the Processing Centers is using ball mills to increase gold liberation. As gold is very fine, it seems that the Cleangold sluice box is an appropriate and affordable technology for the miners and millers to process primary ores via gravity concentration. The introduction of cleaner techniques must come together with better organization of the Processing Centers and changes of the operation procedure. It seems that soon or later the Processing Centers, as in Zimbabwe, will also adopt cyanidation to extract residual gold from tailings. In this case, the environmental problem will be exacerbated, as the mercury will become partially soluble in the final tailings and therefore available for the methylating agents. Intervention of the Government authorities and/or CVG-Minerven to educate and provide assistance to the miners is badly needed otherwise the cyanidation process will be implemented and, without any environmental and health concern, the results will be catastrophic.

Four different types of retorts were manufactured locally and the principle of retorting was demonstrated to miners and millers using Thermex glass retort. The retorts were fabricated using stainless steel crucibles that actually were small salad or sauce bowls acquired in kitchen stores in Puerto Ordaz.

Gold is not melted in the Block B but in the village of El Callao where it is possible to find about 25 gold shops where gold *doré* (i.e. after burning amalgam) is sold and consequently melted. Some of these shops are in family houses. As the gold *doré* may contain up to 10% mercury, as a result of incomplete burning, this mercury is released in the urban environment during melting. This might be contaminating many people in the town.

A two-day workshop was conducted in El Callao on December 8 and 9, 2003. The first day was used to attract the miners and millers to the El Mago Processing Center where UNIDO team set up a series of practical demonstrations for them. In the second day of workshop, a meeting with various stakeholders occurred at the CVG-Minerven Union House (Negra Isidora). With about 50 people (miners, millers, residents, Government representatives, CVG representatives, etc.) all members of the UNIDO project presented partial results of the fieldwork.

A longer and more sustainable project is badly needed in the area. The participation of the mining companies working in El Callao (e.g. CVG-Minerven, HECLA and Crystalex) is crucial to introduce a sound awareness campaign and train miners to reduce mercury pollution.

UNIDO's Transportable Demonstration Units is suggested as a solution to bring hands-on training to miners/millers as well to make the surrounding community aware of the problems related to mercury. Pollution cannot be reduced if miners and millers do not see economic advantages for this. Simple techniques can be brought to the miners' attention in order to reduce mercury emissions and unnecessary exposure.

ACKNOWLEDGMENTS

The Project team wants to express its profound gratitude to the following people and institutions:

- Rebeca Erebrie, Vice-president of Environment, Science and Technology, CVG-Venezuelan Corporation of Guayana and Armando John Madero, Vice-president of Mining, CVG, for their permanent support to the project;
- Franqui Patines, President of CVG Minerven for all information on gold production, and for making possible the use of the Minerven infrastructure;
- Ligia Vos, CVG- Environment, Science and Technology, for her indispensable coordination and unlimited effort to make this project possible;
- Walter Maciel, geologist from CVG-Minerven, for his valuable field support and permanent presence with the UNIDO team on the field;
- Rivero family (Rafael, Maria Elena and Rafaelito) and Antonio "Lalo" for all strength, attention and dedication to the UNIDO team during the processing tests;
- Dr. Salvador Penna (UDO-Universidad del Oriente), Dra Eudelis del Vale Romero Platina and Ms. Aracelis Arevalo (CVG-Minerven) for all support and assistance during the health assessment;
- Luís Perez and Luzmila Sanchez from Fundacion La Salle, for allowing UNIDO team to use their analytical laboratories and for their permanent help in the most difficult phases;
- Luisa de Bermúdez for filming and editing videos on artisanal mining;
- Dr. John Meech from CERM3 – The Center for Environmental Research in Minerals, Metals and Materials of the University of British Columbia, Vancouver, Canada, for making available to the UNIDO team the LUMEX Hg portable analyzer;
- Metall-Technic, Munich, Germany for the donation of the Thermex retorts
- Benjamin Millán, Jesus Rebolledo and Joaquín Lezama, from CVG Minerven for information and field assistance;
- José Pino and Clyde Pepppin, Hecla Mine, for information on ASM in El Callao;
- Jorge Paolini from the Center for Research in Management and Education for the Sustainable Development, UNEG – Universidad Experimental de Guayana;
- All technicians from CVG-Minerven working at the gold assay laboratory;
- All Processing Center's owners and employees that provided information for the UNIDO team: Roberto Clark, Guillermo Herrera, Vladimir Vega, Felix Rangel and Ramon Alvorado among many others.

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INTRODUCTION

In 1995, UNIDO has provided technical assistance related to mercury pollution for Government, companies and artisanal gold miners in the Bolivar State, Venezuela. The situation, as reported by UNIDO in March 1996[1], was extremely serious in El Callao with miners and millers using indiscriminately mercury to amalgamate gold.

The current work was conducted at the end of 2003 for less than one month (from 21 November to 11 December 2003) as a preliminary mission to assess the current health situation and to prepare for a more substantial project to be conducted in the future. The mission assessed the level of mercury intoxication of the miners and surrounding population and introduced simple mineral processing techniques capable of reducing substantially mercury exposure and emission in the region. Technologies to assist informal miners to reduce mercury emission and clean-up polluted sites have been demonstrated to the miners.

The main objectives of the technical assistance were:

- Assess mining methods and mercury use in El Callao region, Venezuela.
- Conduct Health Assessment of people directly involved with mining and mineral processing as well as the surrounding community.
- Evaluate technical needs of artisanal gold miners in the region.
- Evaluate possible local equipment manufacturers and teach them how to manufacture different types of retorts.
- Implement and demonstrate techniques to reduce Hg emissions as well as methods to clean up contaminated tailings.
- Meet representatives of Miners' Association, local authorities, and artisanal gold miners
- Promote a workshop on reducing mercury pollution in small-scale gold mining and avoidance of occupational exposure.
- Initiate an awareness campaign with the public in El Callao.

DEFINITIONS

A wide range of mining and mineral processing activities are classified as artisanal or small-scale mining. This ranges from individual panning to large dredging operations. The definitions and differences between artisanal and small-scale mining differ from country to country and from region to region. Quite often the term "artisanal miner" is applied to make reference just to low-tech manual-migratory panners and the term "small-scale miners" is used for those miners/millers established and often working within the legal framework. The differences between both categories may have some legal implications since some countries prefer to use the term "artisanal miners" to characterize illegal or informal miners. However, even working in legal claims, quite frequently small-miners do not follow the environmental regulations and do not have technical expertise to establish a long-term plan to exploit their gold deposits. Most recent discussions by experts[2] in this theme failed in providing a clear difference between artisanal and small-scale miners. In this case the term **artisanal and small-scale miners** (ASM) is preferred to be used to encompass all small, medium, informal, legal and illegal miners who use rudimentary processes to extract gold from secondary and primary ore bodies. The ASMs work based on instinct, need for feeding his family and paying bills. There is no previous "classical" geological exploration, no drilling, no proven reserves, no ore tonnage establishment and engineering studies. The concept of survival is constantly the driving force for those miners.

[1] UNIDO, 1996. Advisory Assistance on Avoidance Mercury Pollution from Artisanal Gold Mining Operations in State of Bolivar, Venezuela. Prepared by M.M. Veiga, contract SI/VEN/94/801/11-51. 147 p.

[2] MMSD – Mining, Minerals and Sustainable Development, 2002. Breaking New Ground. International Institute for Environment and Development and World Business Council for Sustainable Development. London, UK. 441p.

PROJECT SITE

The southern part of Venezuela, below the Orinoco River, involving State of Bolivar, State of Amazonas and the Federal Territory of Delta Amacuro is called Guayana Region. The main mining activities are conducted in the State of Bolivar which has an area of 240,528 km², comprising 75% of the hydroelectric potential of the country. The number of inhabitants in Venezuela reaches some 24.2 million with a population density of 26.4 persons per km². In 2000, 87% of the population lived in cities and towns with more than 2,500 inhabitants. Less than 5% of the population lived in the Guyana Region. In 1999, the labor force experienced 1.1% decrease in number resulting in an unemployment rate of 13.2% (1,365,752 people). In 2000, 63% of the individuals making up the workforce were men. Unemployment among men reached 12.5%, 1.1% higher than 1999. In 2000, 14.4% of women did not have a job. This was 1.7% higher than in 1999 (CONAPRI, 2003)[3].

In the Bolivar State, with a population of 1,214,486, there are about 15,000 people[4] directly involved in artisanal and small-scale mining (ASM). This includes about 2000 "bateeros" and "suruqueros" who are those miners using pans to extract gold and diamond from alluvial deposits and tailings, 5,000 miners using hydraulic monitors in elluvial and colluvial operations (gold and diamond), 3,000 miners working in hard rocks (quartz veins) and 5,000 miners operating in dredges and rafts in the water streams all over the State.

In Venezuela, hundred fifty years after the beginning of the mining activities, the social and economic situation of the artisanal miners has not changed substantially. Observations of small gold miners in the State of Bolívar, Venezuela, reveal serious effects on family disruption as well as on degradation of the socio-economic conditions of the community.

El Callao is located in the Northeastern part of the State of Bolivar, 150 km from Ciudad Guayana (Puerto Ordaz). Mining tradition started in 1724, when Capuchin priests explored the area. In 1842, the Brazilian expeditionary, Pedro Joaquim de Ayres reported the existence of an auriferous vein on the shores of Yuruari river. The municipality of El Callao was founded in 1853 with the name of Caratal and many small gold mining companies were installed in the region. In 1970, CVG-Corporacion Venezoelana de Guayana[5] incorporated Minerven, a State-owned company, which nowadays has two cyanidation plants producing together approximately 200 to 300 kg of gold/month: Peru Plant processing 5,200 tonnes of material/month and Caratal plant processing 14,000 tonnes/month. About 15% of the Peru Plant material is Hg-contaminated tailings purchased by the company from the artisanal gold miners.

Since the middle of the 19th century, a large volume of cyanidation tailings from old mining operations was deposited at the margins of the Yaruari River for 7 km. This site, known as "Quebrada Mocupia", has called attention of some mining companies interested in re-processing the gold-rich tailings. The Yaruari River is a 100 m wide river with reasonable volume of water in the rainy season but it was told that it is a dead river with no aquatic life. All drainages from the artisanal mining activities flow to the Yaruari River.

El Callao is located 150 km (paved road) from Puerto Ordaz. In the municipality, CVG-Minerven owns a total area of 48,848 ha of mining concessions. The company granted 77 concessions of mining in which 59 are contracts with companies and 18 with individuals. The main portion of

[3] CONAPRI – Venezuelan Council for Investment Promotion, 2003.
http://www.conapri.org/framedetalle.asp?sec=1000&id=26&plantilla=8

[4] Bermúdez D., 2003. El Ambiente y la Salud Ocupacional en la Minería en Pequeña Escala. In: I Encuentro Internacional de Investigación en Salud Ocupacional. Universidad de Guadalajara, Secretaría del Trabajo y Previsión Social (Delegación Jalisco) y PIENSO A.C. Guadalajara, Estado de Jalisco, México. Mayo 2003. (In Spanish).

[5] a rector entity for the Guayana region, to promote and coordinate the social-economic development of the region.

CVG-Minerven mining concession "rented" to third parties is named "Block B" (Fig. 1). With area of 1,785 ha, this site was chosen by the UNIDO for this project. CVG-Minerven has also rented mining areas in Block B to organized companies (e.g. the American company HECLA Mine and the Canadian company, Crystalex).

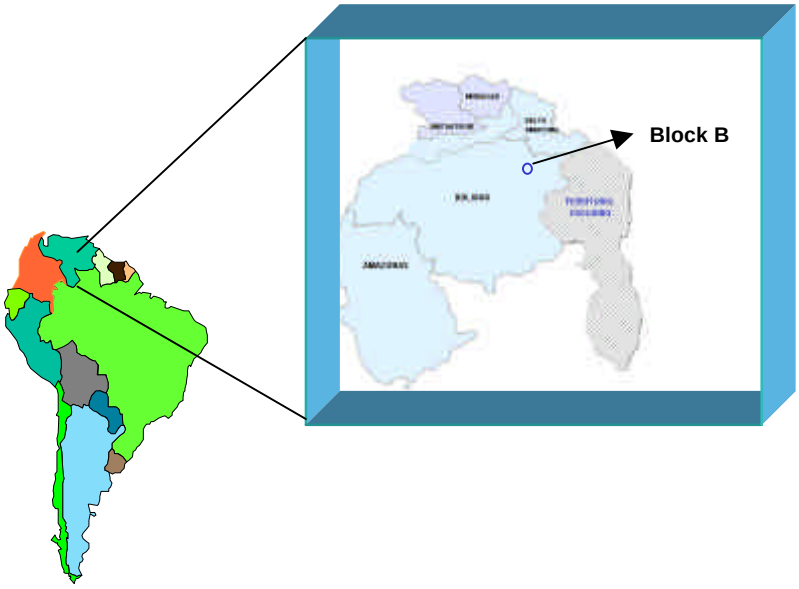


Fig. 1 - Location of Block B (El Callao)

In El Callao, artisanal and small-scale miners (ASM) work basically in the CVG-Minerven concessions. This has been generating employment to the surrounding communities. Since the gold ore is abundant and extremely rich people have not been considering other type of economic activity. The ASM, in some extent, have played the role of gold prospectors for the company. However, not all mining activities are legally carried out within Minerven concessions. Some miners are working outside the Minerven concession or illegally in the company's area, despite the close control from Minerven. As the price of gold has been increased since the end of 2002, the number of ASM has increased substantially in the region and many of them are outsiders who have never had any experience in mining.

Population of Block B

According to the 2001 Census, the total population of El Callao is 17,410 and there are 1731 people living in the Block B, which represents almost 10% of the El Callao population (Hecla, 2004)[6] (Appendix 6). About 47% of the population is female and 44% is younger than 18. The amount of children younger than 15 years old reaches 30% of the population. According to the census conducted by Hecla (2004) individuals with age between 19 and 55 represent 46.5% of the Block B population. In average, the couples in the region have 2.3 sons and daughters and there are 3.5 persons per family. About 1/5 of the population is illiterate and 1/4 does not have any kind of technical education. About 2/5 of the population has primary degree (6^{th} grade), 1/4 secondary degree and just 2% has technical or university degree.

Regarding the type of houses in the area, just 50% of the dwellers have houses built of cement and the rest lives in houses made of wood, zinc sheets, etc. Just 74% of the houses have cement floor and electricity is available for almost 90% of the inhabitants.

[6] Hecla, 2004. Estudio socio-económico de las comunidades del "Bloque B" de El Callao. Compañía Minera Hecla, Estado Bolívar, Venezuela. (In Spanish).

About 30% of the population defines its occupation as students, 21% as unemployed, 19% as housewives and just 15% as miners. However the main activity of the population is definitely gold mining and processing.

Water is available mainly through water trucks (56%) and just 1/3 of the population has water from pipes. About 70% of the population has toilets.

The 5 main communities ("pueblos") in Block B are as follows:

(a) Nuevo México
The total population of this community is 381 inhabitants. About 21% of the dwellers are illiterate and 96% have no formal education related to mining.

(b) La Fábrica
This is adjacent to Nuevo Mexico. With a total population of 359 inhabitants about 20% are illiterate and 90% have no technical education.

(c) Monkey Town
This community has 433 inhabitants and has similar characteristics to Nuevo Mexico related to education. About 20% of the population has been working in mining.

(d) Peru-Chile
There are about 411 people living in this community with more than 94% with age under 55 (50% under 18). Also 20% of the individuals have characterized themselves as miners.

(e) La Iguana
This community is located at the end of the main road Caratal-Chile with a population of 147 inhabitants. More than 42% of the individuals are illiterate and almost the totality does not have technical education. Only 45% of the families have electricity.

Table 1 – Main Characteristics of the Population of Block B

	CHILE	**LA FABRICA**	**LA IGUANA**	**MONKEYTOWN**	**NVO MEXICO**
Number of inhabitants	411	359	147	433	381
%Females	45.5	52.9	33.3	47.1	47.5
Main age group	Under 18 (50%)	Between 19 and 55 (51%)	Older than 56 (40%)	Between 19 and 55 (49%)	Under 18 (47%)
Average number of sons per family	2.4	2.4	1.3	2.2	2.6
% Man living with woman	46.6	72.4	42.9	67.4	71.6
Average number of people per house	3.7	3.7	2.5	3.6	3.7
% Illiterates	27.7	19.5	42.2	18.0	21.0
% Individuals with no technical education	98.1	90.0	99.3	96.1	96.1
Main education level	83% Primary	73% Primary-secondary	90% Primary	75% Primary-secondary	72% Primary-secondary
Main occupation	Unemployed - Miner	Unemployed - Miner	Unemployed-Framer	Miner - Unemployed	Unemployed - Miner
Main type of house	Zinc - Wood	Cement - Mud	Zinc -Cement	Cement - Wood	Cement - Mud
Main type of roof	Zinc	Zinc	Zinc	Zinc	Zinc
Main type of floor	Cement - earth	Cement	Earth - cement	Cement	Cement
% Houses with electricity	96.5	92.1	44.9	99.0	93.8
Main source of water supply	Truck	Pipe - truck	Creek - pipes	Truck	Pipe - truck
Main sanitation	Bush - toilet	Toilet	Bush	Toilet	Toilet

PROCESSING CENTERS

About 250 artisanal-small scale miners (ASM) in Block B excavate the ore from 30-80 m deep shafts using explosives and transport it in small trucks to the Processing Centers (locally known as "molinos") to be crushed, ground, concentrated and amalgamated. About 30% of the ore entering Block B comes from areas located outside of Block B such as Block C (North) and Block A (East).

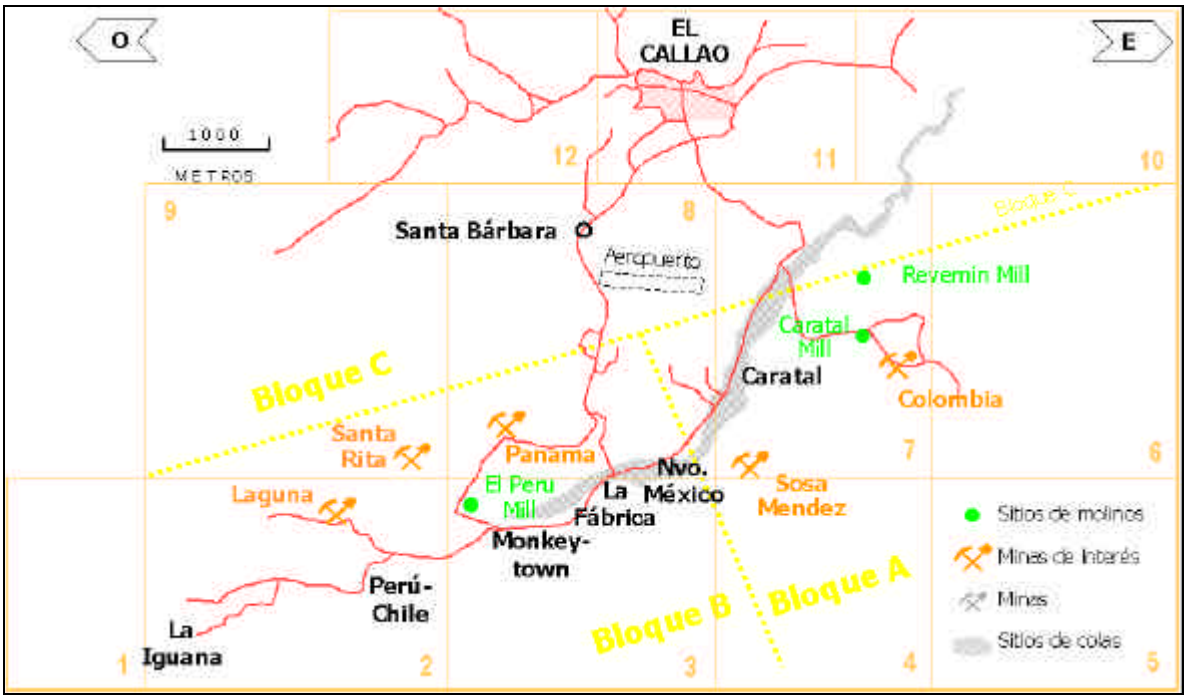


Fig. 2. Location of the Different Communities in Block B

In the Block B area there are 28 operating Processing Centers, each one with 3 to 6 hammer mills making a total of **86 active hammer mills and 25 jaw crushers** in the region. As miners transport ore in 50-kg polyethylene bags, it is common in the region to refer to gold grade by "grams of gold per bag". Miners pay 10% of the recovered gold to the millers, known as "molineros" (Center owners). The material is crushed in jaw crushers and wet-ground below 1 mm in 25 HP hammer mills. The whole ore is amalgamated in copper plates. The distribution of the Processing Centers in the Block B was investigated. The Centers are located in 4 communities along the main road Caratal-Chile. It was observed that 94% the Processing Centers are located in the communities of Nuevo México and Monkey Town. From East to West the Processing Centers are located at (Fig. 2):

(a) Nuevo México
Most miners from this area are legal and organized in an association named Civil Association of the Small Miners of El Callao (ASOCIPEMICA). The auriferous material extracted by miners comes from the Santa Rita Mine (Concession Minerven 2). The concessions in Nuevo Mexico are granted to 11 milling companies (Processing Centers) and they have a total of 43 hammer mills and 12 jaw crushers (Appendix 1).

(b) La Fábrica
This is adjacent to Nuevo Mexico. Many miners from this small community belong to ASOCIPEMICA. The presence of some illegal miners living and working on the site was informed. In this community there are 2 Processing Centers for a total of 5 mills and 2 crushers.

(c) Monkey Town
There is a clear predominance of males working at the Processing Centers in this community. Most miners belong to ASOCIPEMICA, however there are some illegal miners as well. There are 11

Processing Centers with a total of 38 hammer mills and 11 jaw crushers. According to the census conducted by Hecla (2004), there is no Processing Center in Peru-Chile.

(d) La Iguana
The economic activity in this sector is fundamentally agriculture. However, in dry season some people conduct alluvial gold mining mainly in the La Iguana creek.

MERCURY USE

The primary ore is transported to the Processing Centers were millers crush it below 2 inches with jaw crushers and make a heap to feed the hammer mills. There is no concentration process, i.e. the ore is ground to –1 mm in hammer mills and passed on copper-amalgamating plates. Mercury is widely used in these plates to trap gold specks. Interestingly that the millers have built at the exit of the mill a riffle (known as "check") with a short piece of wood wrapped with a piece of cloth. This is filled with mercury before starting the grinding operation. At the end of the milling process the riffle is removed and the trapped gold with mercury flows on the copper plates. Amalgamation plates are stationary copper sheets usually dressed with a thin layer of mercury (usually 150g Hg/m² of plate) used to amalgamate free gold particles in ores ground coarser than 1.5 mm. Working with slope of 10%, these 1.5 to 2 m-long plates receive pulp of auriferous ground ore (10 to 20 % of solids) and the amalgamation takes place when gold particles contact the plate surface. The velocity of flow has to be sufficiently low that the precious metal particles can sink to the plate surface and yet high enough that other mineral constituents of the ore do not remain on the plate. The efficiency of the process depends on the operator ability, but usually is low due to the short time of ore-mercury contact. The method works better for alluvial gold but it is very limited for primary ore in which quite often gold is not completely liberated from the gangue minerals. About 0.3 m^2 of plate is required to treat 1 tonne of ore/24 h for pulps with 20% solids. Abrasion of the mercury surface releases droplets which go out with the pulp. Acidic water may also cause yellow or green spots on the copper plate and mercury is also lost. Miners refer to these discolored areas as "mercury sickness". A large majority of artisanal miners in El Callao do not use a mercury trap at the end of the plates. So, tailings from Cu-plates typically contain 60 to 80 ppm Hg.

Periodically the process is interrupted and amalgam is scraped off from the plates with a sharp piece of metal. At this stage, miners are exposed to high levels of Hg vapor. Quite often the Venezuelan miners burn the amalgamation plates to "remove" fine gold trapped on the plate. The amalgam recovered from the plate is squeezed to eliminate excess mercury and burned on a tray or a shovel. Some millers have good retorts available for miners but they argue that the retorting time is too long (15 minutes) and they simply use a propane blowtorch to decompose amalgam, emitting large amount of mercury to the atmosphere and exposing themselves to mercury vapor. This is clearly contaminating everyone directly involved in the ore processing as well as their neighbors, since the Processing Centers are very near the houses.

In general, the metallic mercury used in Block B comes from Brazil and it is not legally sold in the region. Miners also use mercury recycled in Venezuela but it contains many impurities. It is observed that typically a Processing Center buys (and loses) 6 to 8 kg of Hg/month. Mercury is sold in the area at a price around US$ 20-25/kg which is 5 to 6 times higher than the international market price. Millers provide mercury for the miners who add further mercury to the plates during operation. The ratio Hg_{lost}: $Au_{produced}$ is around 1.5 to 2. **The mercury emission in Block B is estimated to be between 2 and 4 tonnes/a**. In all El Callao, the mercury emission can reach as much as 12 tonnes/a.

This work did not attempted to assess the environmental problems caused by mercury used in the Block B. However it is clear that the runoff water coming from the Processing Centers raises environmental concerns. The water passes through the Hg-contaminated tailings to go to the

Yuruarí River, which supplies water to the population of El Callao and nearby communities. The high level of organic matter in the region associated with large amount of Hg-contaminated suspended particles being carried by the water creates conditions to oxidize and complex the metallic mercury released by miners. Soluble Hg-organic complexes may eventually be transformed into the most toxic form of mercury, methylmercury[7]. However, the eventual bioaccumulation of methylmercury in the region seems to be of less impact for humans than the occupational exposure of metallic mercury vapor since just a few small fish are found in the water streams and (local) fish are not a staple food for locals.

GOLD PRODUCTION

The ore in El Callao is usually extremely rich, with grades ranging from 12 to 20 g Au/tonne. Interviewing various millers, it was observed that a Processing Center produces on average 100 to 200g Au/day (2.6 to5.2 kg/month). The daily gold production can reach as much as 1 kg/day depending on the type of ore being processed. Based on the average gold production reported by the interviewed millers, **the Block B production might be around 1 to 2 tonnes Au/a** considering that there are 28 active Processing Centers in the area. In all El Callao, the gold production can reach as much as 5 to 6 tonnes/a considering that there are 80 to 90 Processing Centers in all region. According to CVG engineers, as gold is very fine (below 0.074mm), artisanal miners cannot reach the liberation size using hammer mills and in the amalgamation process just 30% of the gold is trapped. The rest is sent to the tailing ponds and later sold to the mining companies.

The hammer mills have capacity of grinding 0.2 to 0.4 tonnes/hours depending on the ore hardness. Then, all 86 hammer mills together in El Callao can process a maximum of 344 tonnes of ore/day or, considering 300 days/a, they have the grinding capacity of processing up to 103,000 tonnes/a of soft ore. In fact, after interviewing millers, the actual amount of material ground by each hammer mill is 1.7 to 2.5 tonnes/day/hammer mill or 5 to 7.5 tonnes/Processing Center/day. Considering 86 mills and 300 working days per annum, the amount of processing material in Block B might be between 44,000 and 65,000 tonnes/a.

Gold is not melted in the Block B but in the village of El Callao where it is possible to find about 25 gold shops where gold *doré* (i.e. after burning amalgam) is sold and consequently melted. Some of these shops are in family houses. As the gold *doré* may contain up to 10% mercury, as a result of incomplete burning, this mercury is released in the urban environment during melting.

The price of gold paid to miners is around US $10/g in Venezuelan currency (Bolivars) at the official exchange rate. As the US dollar in the black market reaches prices at least 70% higher than the official rate, it is clear that miners are selling gold in the neighbor countries, e.g. Brazil.

COSTS OF THE ARTISANAL GOLD MINING ACTIVITY

After visiting 6 Processing Centers an average operating cost was obtained and discussed with Mr. José Pino, HECLA, and Mr. Joaquín Lezama, CVG-Minerven. The mining and milling costs are quite dependent on the type of ore being processed. Hard ores consume almost five times more hammers than soft ores (Table 2). The operating costs were transformed into grams of gold per tonne of ore processed using the following rate: Bs 2700 = US$ 10 = 1g Au.

[7] Meech,J.A., Veiga,M.M., Tromans, D., 1998. Reactivity of Mercury from Gold Mining Activities in Darkwater Ecosystems. *Ambio* , v.27, n.2, p.92-98.

The life of the hammers depends on the ore hardness. For soft material, a pair of hammers made of cast-iron and costing US$ 8 to 10 can grind 10 tonnes of ore before being changed. Grinding hard ores, the hammers are changed after grinding 1.5 to 2 tonnes (around 30 to 40 bags of 50 kg) of ore. This represents a major cost of the milling operation (as high as 65% of the operating costs), however, millers do not charge more for milling hard ores.

Table 2 – Estimate Operating Cost of a Processing Center in El Callao

MINE	**Operating Cost (gAu/tonne)**
Drilling	0.1
Explosives	1
Bags to transport ore	0.3
Food for labor	0.4
(Labor, when miners are employed)	0.3
Subtotal Mine	**2.1**
MILL	
Electricity	0.06
Maintenance	0.14
Mercury	0.14
Hammers	0.09 (soft ore) 0.63 (hard ore)
(Labor, when millers are employed)	0.3
Sub total	**0.73 (soft ore) 1.27 (hard ore)**
TOTAL	**2.83 (soft ore) 3.37 (hard ore)**

Each Processing Center counts with 3 to 5 “employees” who usually do not receive salary but just live out of the gold left (trapped) inside the hammer mills. At the end of the day the “employees” open the mills and clean them on the amalgamation plates to recover their earnings. Considering that most Processing Centers do not pay their employees, the operating cost of a Processing Center must be between 0.43 g Au/tonne and 0.97 g Au/tonne. As the “molinero” (mill owner) receives 10% of the gold produced, his/her break-even is reached when processing ores with 0.24 and 0.5 g Au/bag for soft and hard ore respectively or 2.4 and 5 “points of gold per bag”, using local terms. Many miners do not acknowledge this and they work below the break-even point. It is clear that the “molineros” must change their procedures of charging for milling. As in many circumstances miners bring very-low-gold-grade ore to be processed and millers do not receive anything after all. They should, for example, adopt the method used in Zimbabwe by the Milling Centers of charging a fixed price per hour of grinding. The Zimbabwean millers charge US$ 2.86/hour (for soft ore) and US$ 4/hour (hard ore) when using either stamp or ball mills.

TAILINGS

Millers accumulate tailings in their ponds and sell it to CVG-Minerven and eventually to other companies applying cyanidation to extract residual gold. The State-owned company re-grinds the tailings to below 200 mesh (0.074mm) and leaches the material with cyanide. Tailings containing in average 60 to 80 ppm of mercury go to the CVG plant and the plant operators do not have control of mercury in the effluents or in the gold melting room. This mercury is definitely contaminating plant operators and reducing the efficiency of the gold precipitation on zinc dust (Merrill-Crowe Process). The tailings in El Callao are extremely rich in gold and CVG-Minerven purchases tailings based on gold content. The company does not buy tailings with less than 6g Au/tonne. They pay for tailings with 6, 12 and 20g Au/tonne, 30%, 40% and 50% of the value of pure gold respectively. As the amount of tailing produced is equal to the amount of material ground (see above), the

production of tailings in the Block B must be between 44,000 and 65,000 tonnes/a. Considering an average grade of 7 g Au/tonne (which is low for El Callao), the amount of gold going to the tailings per annum in the Block B is around 308 to 455 kg. This divided by 28 Processing Center owners, gives 11 to 16 kg Au/per owner. As the company pays for tailings around 30% of the gold value (1 g = US$13.6 New York Market on April 7, 2004), a miller would receive at least something between US$ 44,880 and US$ 65,280 per annum when selling his/her tailings. This is might be the minimum received by miners since the companies do not buy tailing with grade below 6 g Au/tonne. This is clear a better business for the Processing Center owners than the processing operation itself, where they receive 10% of the gold production. The miners and the employees of the Processing Centers are the main victims of this unfair system.

HEALTH ASSESSMENT

Justification

The main ways pathways in which mercury is bioaccumulated in humans are through metallic mercury vapor from amalgam burning (and gold melting) and ingestion of fish with high methylmercury concentrations. Due to limited resources of this preliminary project, and knowing that fish is scarce in the streams and a luxury food for the local population, an environmental assessment to evaluate the possibilities of Hg bioaccumulation was not conducted. However, knowing that Hg vapor is the main problem in the area, a detailed health assessment was conducted to provide indications of the level of mercury intoxication on ASM communities exposed to mercury vapor. The health assessment combined information from total Hg concentration in **urine** with **medical exams** to evaluate the level of impact that the pollutant caused or may cause to individuals residing in this "mining and environmental hotspot". This is a basic procedure to establish risks and prioritize mitigation actions.

Inhalation of Hg vapor is more significant for mining and gold shop workers directly involved in handling metallic mercury, but can also indirectly affect surrounding communities. Once in the lungs, Hg is oxidized forming Hg (II) complexes, which are soluble in many body fluids. The ultimate effect of Hg and related compounds is the inhibition of enzyme action[8] (Jones, 1971). Oxidized mercury can easily diffuse across the blood-brain barrier, which is a series of multiple systems which regulate the exchange of metabolic material between brain and blood. Impairment of the blood-brain barrier, together with the possible inhibition by Hg of certain associated enzymes will certainly affect the metabolism of the nervous system[9].

Hg vapor is completely absorbed through the alveolar membrane and complexes in the blood and tissues before reacting with biologically important sites. The biological half-life of Hg in blood absorbed as vapor is about 2-4 days when 90% is excreted through urine and feces. This is followed by a second phase with a half-time of 15-30 days[10]. The time interval between passage of elemental Hg through the alveolar membrane and complete oxidation is long enough to produce accumulation in the central nervous system[11]. Mercury can irreversibly damage the nervous system. Kidneys are the most affected organs in exposures of moderate duration to considerable levels, while the brain is the dominant receptor in long-term exposure to moderate levels. Total mercury elimination through urine can take several years. Then, the Hg levels in urine would not be expected to correlate with neurological findings once exposure has stopped. A short-term exposure to high levels causes

[8] Jones,H.R., 1971. Mercury Pollution Control. Noyes Data Co., New Jersey, 251p.

[9] Chang, L.W., 1979. Pathological Effects of Mercury Poisoning. *In*: The Biogeochemistry of Mercury in the Environment. p.519-580. Ed. J.O. Nriagu. Elsevier/North-Holland Biomedical Press, Amsterdam.

[10] WHO - World Health Organization, 1991a. Environmental Health Criteria. 118. Inorganic Mercury. Geneva, Switz: World Health Organization. 168p.

[11] Mitra, S., 1986. Mercury in the Ecosystem. Trans Tech Publ., Netherlands. 327p.

clinical symptoms which mainly involve the respiratory tract. Mercury levels in the urine of new workers should be lower than those of workers with a longer duration of exposure[12].

Symptoms typically associated with high, short-term exposure to Hg vapor (1000 to 44,000 µg/m³), such as those miners are subjected to when they burn amalgams in open pans, are chest pains, dyspnoea, cough, haemoptysis, impairment of pulmonary function, and interstitial pneumonitis. The common manifestation of chronic exposure to excessive levels of Hg vapor is metallic taste and gum diseases such as gingivitis, ulcers and formation of a blue line at gum margins (Stopford, op. cit.). Long-term, low-level Hg vapor exposure has been characterized by less pronounced symptoms of fatigue, irritability, loss of memory, vivid dreams, and depression (WHO, op. cit.). Occupational exposure of mercury has resulted on effects on the central nervous system. Acute exposure has caused delirium, hallucinations and suicidal tendency as well as erethism (exaggerated emotional response), excessive shyness, insomnia, and in some cases muscular tremors. The latter symptoms are associated with long-term exposure to high levels of Hg vapor. In milder cases, erethism and tremors regress slowly over a period of years following removal from exposure pathways (WHO, op. cit.). A person suffering from a mild case of Hg poisoning can be unaware because the symptoms are psycho-pathological. These ambiguous symptoms may result in an incorrect diagnosis.

Experiments with animals indicate continuous exposure to Hg above 0.3 µg/m³ of air may present a health hazard. Acute Hg poisoning, which can be fatal or can cause permanent damage to the nervous system, has resulted from inhalation of 1,200 to 8,500 µg/m³ of Hg (Jones, op. cit.).

Since inorganic Hg poisoning affects liver and kidneys, high Hg levels in the urine can indicate undue exposure to Hg vapor. WHO (op. cit.) collected a large amount of evidence to conclude that a person with a urine Hg level above 100 µg/g creatinine has a high probability of developing symptoms such as tremors and erethism (abnormal irritability). For Hg levels between 30 and 100 µg/g creatinine, the incidence of certain subtle effects in psychomotor performance and impairment of the nerve conduction velocity can increase. The occurrence of several subjective symptoms such as fatigue, irritability, and loss of appetite can be observed. For Hg levels below 30-50 µg/g creatinine, mild effects can occur in sensitive individuals but it seems more difficult to observe symptoms.

The WHO (1991 – op. cit.) described a relationship between Hg in air (A) ion µg/m³ and in urine of exposed workers (U) expressed as µg/g creatinine: $U = 10.2 + 1.01\ A$. Thus a person exposed to about 40 µg/m³ of Hg in air should show levels of Hg in urine around 50 µg/g creatinine. This is the maximum urine Hg concentration recommended by WHO. Drasch *et al* (2002)[13] consider the Hg level in urine of **5 µg Hg/g creatinine an *alert* value** and **20 µg Hg/g creatinine as an action level.**

Sampling and Analyzing Urine

The ideal urine sample is the first one in the morning. This analysis reflects mercury excreted by the body during the night. However collection during early morning is not always possible and spontaneous urine can also be collected without dramatically affecting results. In order to avoid dilution of urine samples and for comparison of results, the mercury concentrations in urine must be corrected to the creatinine excretion.

Creatinine is a breakdown product of creatine, which is an important constituent of muscle. Creatinine is excreted from the body entirely by the kidneys. With normal kidney function, the

[12] Stopford, W., 1979. Industrial Exposure to Mercury. *In*: The Biogeochemistry of Mercury in the Environment. p.367-397 Ed. J.O. Nriagu. Elsevier/North-Holland Biomedical Press, Amsterdam.

[13] Drasch, G.; Boese-O'Reilly, S.; Maydl, S.; Roider, G., 2002. Scientific Comment on the German Human Biological Monitoring Values (HBM Values) for Mercury. *Intern. Journal Hygiene Environmental Health*, v. 205, p. 509-512.

serum (blood) creatinine level should remain constant and normal. Normal values are highly dependent on the age and lean body mass of the person the urine is being collected from. Urine creatinine (24 hour sample) values may therefore be quite variable and can range from 500 mg/day to 2000 mg/day. A healthy range for creatinine in spot urine is from 25 to 400 milligrams/deciliter (mg/dL)[14]. Urine creatinine (24 hour sample) values may be quite variable and can range from 500 mg/day to 2000 mg/day. The level of creatinine in a 24-h urine sample ranges from 8 to 22mg/dL/kg of body weight for children, from 11 to 20 mg/dL/kg b.w. for women and from 14 to 26 mg/dL/kg b.w. for men. So a man weighing 70 kg has a normal level of 24-hour urine creatinine ranging from 980 mg/dL to 1820 mg/dL. As the creatinine concentration is usually expressed in mg/dL, dividing the result by 100 the unit is transformed into g/L. As the result of Hg in urine is usually expressed in µg Hg/L of urine, then dividing this by g/L of creatinine, the final result is expressed in µg Hg/g of creatinine, which is the usual unit.

The urine samples in the Block B were collected in 50 mL vials and immediately transported in coolers to a freezer were they were frozen to –20 °C waiting for analysis. The samples were then naturally melted and a sub-sample obtained for analysis. The total mercury analyses were processed using LUMEX[15] portable atomic absorption spectrometer (RA 915+) coupled with a pyrolisis chamber (RP 91C). The equipment works according to the principle of the thermal destruction of the sample followed by the determination of the amount of elemental mercury released. A small volume of urine sample, in this case 100 µL, was obtained with a micro-pipette, introduced in a quartz crucible and then into the pyrolisis chamber (RP 91C). This has two sections that heat independently to temperatures around 800ºC. The vapor released in the pyrolisis chamber enters the atomic absorption spectrometer (RA 915+). All procedures were controlled by a lap top computer. LUMEX uses a Zeeman process (Zeeman Atomic Absorption Spectrometry using High Frequency Modulation of Light Polarisation ZAAS-HFM) that eliminates interferences and does not use a gold trap. The detection limit reported by the manufacturer for sediments is 0.5 µg Hg/kg (ppb) using 200 mg of sample in the pyrolisis chamber. The detection limit of the urine samples established in the Venezuelan analytical conditions was 0.2 µg Hg/L. This equipment was able to analyze 300 urine samples in 12 hours.

Creatinine analysis was performed using a kit Bioclin from the company Quibasa. Creatinine reacts with picric acid, to form a yellow-reddish chemical complex in conditions that the maximum production of the dyed complex creatinine-picrate occurs (Appendix 3). The spectrometric analyses were conducted at wavelength of 510 nm in a spectrophotometer Bausch & Lomb Spectronic 20.

Interlaboratorial

In order to evaluate the LUMEX analytical precision, urine samples from 15 selected volunteers were collected and analyzed using LUMEX, and sent to 3 Venezuelan institutions named Laboratorio de Espectroscopia Molecular, Facultad de Ciencias, Universidad de los Andes (ULA), La Salle Institute, and UCV-Universidad Central de Venezuela (Caracas). The analytical method used by ULA and UCV was cold vapor atomic absorption spectrometry. La Salle used atomic absorption spectrometry with hydride generation.

[14] Moran, D.T., 2003. Creatinine-urine. Medical Tests Encyclopedia. http://health.discovery.com/diseasesandcond/encyclopedia/1159.html

[15] This equipment was kindly provided by CERM3 – The Center for Environmental Research in Minerals, Metals and Materials of the University of British Columbia, Vancouver, Canada

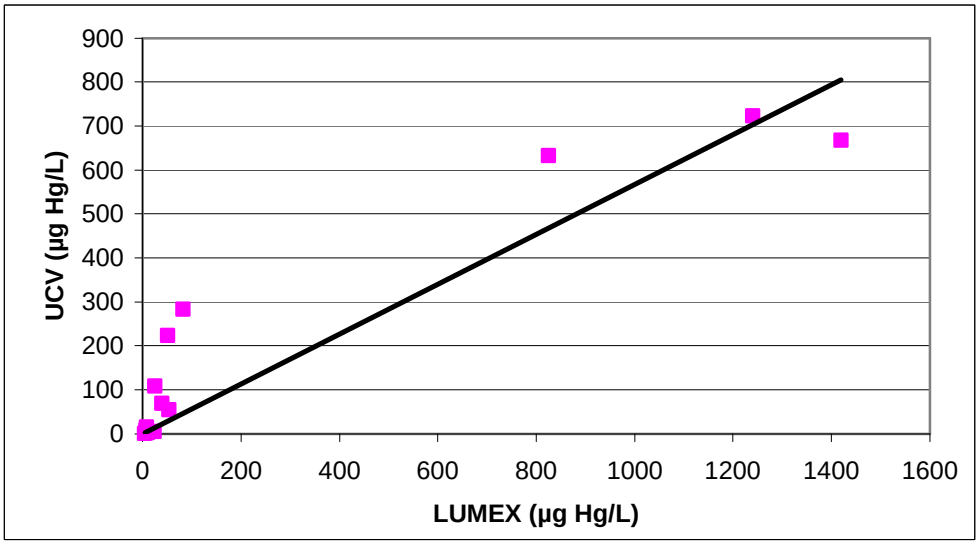


Fig. 3 - Comparison between LUMEX and UCV Results

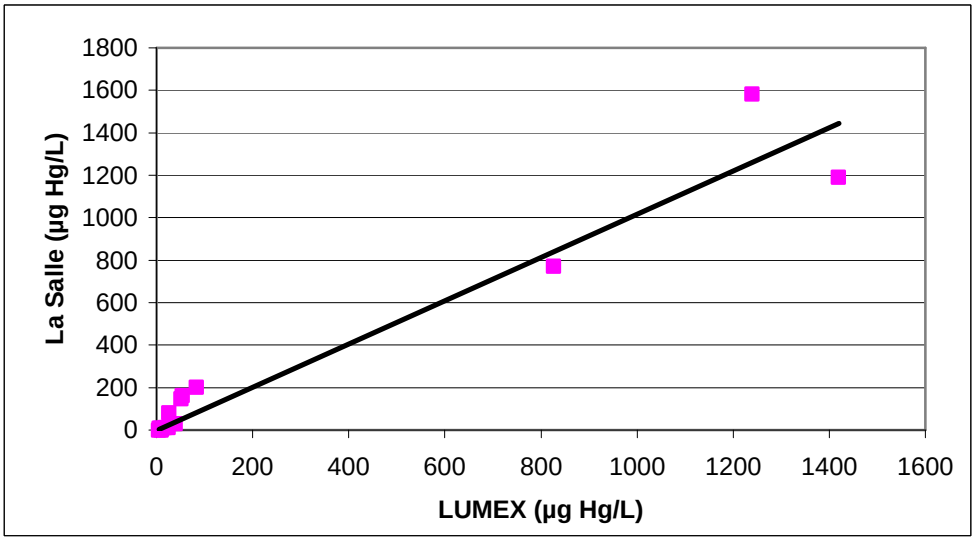


Fig. 4 - Comparison between LUMEX and La Salle Results

The *linear correlation coefficients (r)*[16] between Hg analyzed by LUMEX and the results from the Venezuelan laboratories were: 0.8868 (ULA), 0.9178 (UCV), 0.9690 (La Salle). This indicates a relatively good performance of the portable analyzer. However the largest discrepancies occurred among the Venezuelan laboratories (Appendix 5). There are many reasons for this, such as: type of analytical equipment, analytical procedure, quality of reagents and water, cleanliness of the laboratory glassware and environment (in particular air), quality of standards, quality control procedure, stability of the electricity source, etc. It is important to establish a high level committee in Venezuela to look after issues related to mercury analysis to create a reference laboratory and improve the analytical quality of the existing labs.

Medical Exams

A Health Assessment is an epidemiological research project and therefore involves evaluation of the physical and mental conditions of individuals and possible influences of external factors that may or may not contribute to the aggravation of their health. Medical exams are usually designed to establish a relationship between biomonitoring materials (e.g. analysis of urine) and symptoms of poisoning, which in rough terms can be described as a dose-response procedure.

[16] also referred to as the *Pearson product moment correlation coefficient*

For a neurotoxicant such as metallic mercury, current epidemiological (and clinical) practices examine a continuum of responses by severity from subtle responses to very frank adverse outcomes. Symptoms can be very subjective, influenced by many confounding factors and are not always identified in a medical interview.

The medical exam followed the Protocols developed by UNIDO[17]. Questions related to health history of the volunteers were applied in order to exclude participants with severe diseases from the statistical evaluation (e.g. someone who has had a stroke might be excluded from the survey). Individuals were selected for a series of specific neuropsychological tests designed to detect effects of mercury poisoning. These tests were applied by Dr. Heloisa Pacheco-Ferreira, doctor neurotoxicologist, professor of the Dept. of Preventive Medicine - Faculty of Medicine, Federal University of Rio de Janeiro (DMP/FM/UFRJ and NESC/UFRJ), Brazil. Local health care professionals[18] followed the exams. Dr. Pacheco-Ferreira has also dedicated 5 mornings to discuss the UNIDO protocols with local doctors and nurses, giving emphasis to the physiopathological mechanisms of metallic mercury in the human body.

The work also comprised a comprehensive explanation of the work objectives to the volunteers. A doctor from the local Medical Association (Dr. S. Penna) has participated in all steps of the Health Assessment. All persons involved in the medical exams have signed an agreement to participate in the Health Assessment involving four questionnaires/exams:

1. evaluation of risk of mercury exposure (personal data, occupational exposure to mercury, confounding factors to exclude candidates with other problems, diet issues frequency and type of food)
2. general health (questions related to health conditions and subjective symptoms as described by the patient, e.g. metallic taste, salivation, fatigue, etc)
3. clinical-neurological exams (e.g. blood pressure, signs of gingivitis, ataxia, tremors, reflexes, etc.),
4. specific neuropsychological tests (e.g. memory, coordination, etc.)

All the results of these questionnaires/exams were compared with the mercury analysis in urine samples. All the procedures were clearly explained to the population. All questionnaires were translated to Spanish.

The clinical-neurological exams, a fundamental part of the assessment of the evolution of metallic mercury exposure, allow the observation of the speech problems, walking, balance, coordination, muscular strength, sensibility, autonomous features of the cranial and spinal nerves, superficial and profound reflexes and other features.

Specific neuropsychological tests were applied to test and evaluate:

- recent memory, using the Wechsler Memory Scale (WMS),
- episodic memory
- fine motor coordination using the MOT Test (match box),
- coordination and dexterity of the hand
- spatial perception,
- fine motor and manual dexterity

[17] Veiga, M.M. and Baker, R., 2004. Protocols for Environmental and Health Assessment of Mercury Released by Artisanal and Small-Scale Gold Miners (ASM). GEF/UNDP/UNIDO Global Mercury Project. UNIDO Project EG/GLO/01/G34. Vienna, 214 p.

[18] Dr. Eudelis del Vale Romero Platina (from CVG-Minerven) and Dr. Salvador Penna (UDO-Universidad del Oriente) followed all steps of the medical exams

- motor- visual coordination
- perception of the background figure,
- perception of the constancy of forms,
- visual perception (Frostig).

The questionnaires related to mercury exposure and to general health were applied by a local nurse. The clinical-neurological exams were conducted by a local physician and Dr. Ferreira (neurotoxicologist). The specific neuropsychological tests were also applied by Dr. Ferreira. The simplest questionnaires were applied in the field (Processing Centers) and the medical exams in El Callao at the house of the Miner's Union (CVG-Casa Negra Isidora).

Selection of Volunteers

The volunteers for the Health Assessment were preliminary selected based on the population distribution of the different communities of Block B (Table 3) and based on previous work conducted by Hecla Mine (op. cit.) that defined the demographic distribution. About 500 possible volunteers were identified in a proportion of 40% men, 30% women and 30% children. Out of the 500 people identified (Table 3), 165 were selected for the application of the first questionnaire, risk of mercury exposure. Urine collectors were given to these volunteers. Additional urine samples were collected to be used in the interlaboratorial analyses. A total of 209 urine samples were analyzed by LUMEX (Appendix 2).

Table 3 - Population Distribution in Block B

Community	Total inhabitants	Possible volunteers	% of the total sample
Nuevo México	381	110	22
La Fábrica	359	104	21
Monkey Town	433	125	25
Chile	411	119	24
La Iguana	147	42	8
TOTAL	**1737**	**500**	**100**

Table 4 - Number of Volunteers that Responded the Four Questionnaires

Individuals	Quest. 1	Quest. 2	Quest. 3	Quest. 4
Millers (males)	42	42	42	38
Miners (males)	71	37	37	35
Miners (females)	2	2	2	0
Community women	50	50	50	32
Children			8	0
Total	**165**	**131**	**139**	**105**

Most male volunteers have been working in the Processing Centers and/or in the mines. The distinction between millers and miners is that millers work exclusively as "employees" of the Processing Centers whereas miners extract the ore, take it to the Centers and follow all concentration steps with the millers. Both workers are contaminated by mercury vapors but millers are constantly in contact with mercury while miners spend some time in the mines. Both burn amalgam using blowtorches. All male miners and millers were older than 15 and younger than 50. Women were selected according to the proximity from their residences to the Processing Centers: 100m, 200 m, 400m, etc. Their ages ranged from 15 to 45. It was selected children living in the same house as their mothers. All children were younger than 15.

A total of 165 volunteers have answered the questionnaire 1, and, after applying the exclusion criteria, just 105 persons were selected to perform the neurophysiological tests (questionnaire 4) (Table 4). A total of 209 samples of urine (66 from women, 62 from children, 48 from millers and 33 from miners) were collected and analyzed for Hg and creatinine.

Results of Urine Analysis

The overall average of total Hg concentration in 209 samples analyzed, was 104.59 µg Hg/g creatinine with standard deviation of 378.41 µg Hg/g creatinine.

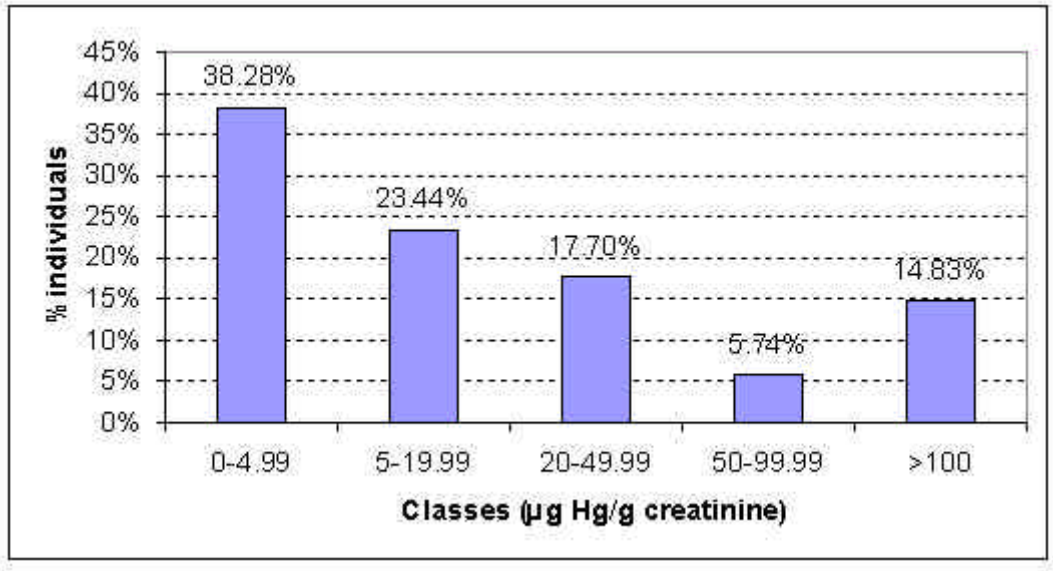


Fig. 5 - Classes of Hg Concentrations in Urine

Classes of Hg concentrations were selected to highlight the results (Fig. 5). The first class consists of individuals with levels of total Hg in urine below 5 µg Hg/g creatinine, herein referred as ***alert*** level. About 38% of the sampled individuals are included into this class, in which 79% are non-workers (women and children), 15% are miners and 6% millers. The second class comprises Hg levels between 5 and <20 µg Hg/g creatinine. About 23% of the individuals showed Hg levels within this class. This was more significant among miners, women and children (24%) (Fig. 6). The third class consists of Hg levels in urine above the ***action*** level (20 µg/g creatinine) but still below the ***maximum*** of 50 µg/g creatinine recommended by the World Health Organization. About 18% of the sampled individuals are classified in this class, in which miners, women and children are the main representatives of this class. The fourth class consists of individuals with Hg levels in urine above 50 µg/g creatinine but still below 100 µg/g creatinine. Around 6% of the individuals have shown concentrations in urine at this level. The last class encompasses individuals with Hg in urine above 100 µg/g creatinine which is the concentration in which neurological symptoms of mercury intoxication should be evident. About 15% of the sampled individuals had Hg in urine above this concentration.

About 38% of the sampled individuals had Hg in urine above the ***action*** level of 20 µg Hg/g creatinine. The situation with miners and millers is dramatic as 30% and 79% of the miners and millers respectively have Hg in urine above the ***action*** level and 52% of the millers have levels above 100 µg/g creatinine. In addition, about 14.6% of millers had shown extremely high mercury concentrations in urine, ranging from 1221 to 3260 µg Hg/g creatinine. This result allows the generalization that more than 90% of the sampled individuals working in the Processing Centers (millers) have Hg levels in urine above the ***alert*** level.

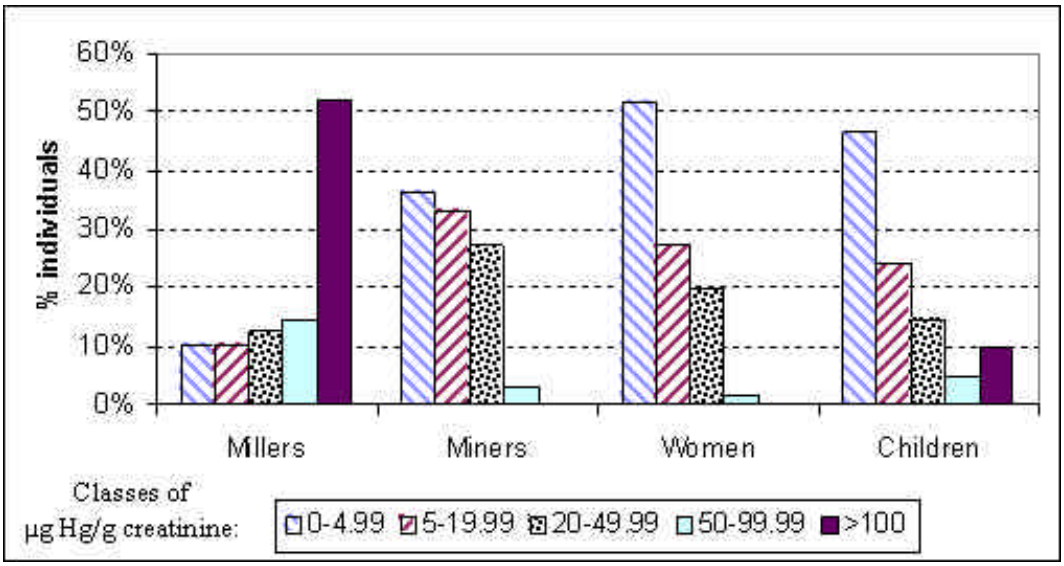


Fig. 6 - Distribution of Hg in Urine

Mercury in Urine from Women

The average level of Hg in urine from 66 women sampled in this study was 13.02 with standard deviation of 23.34 µg Hg/g creatinine. About 27% of the women had Hg concentration in urine above the ***alert*** level and 21% above the ***action*** level.

Table 5 - Average of Total Mercury in Urine Samples from Women
(µg Hg / g creatinine)

Community	Average	S.D.
Monkey Town	16.35	33.25
La Fábrica	4.94	7.12
Chile	9.81	9.41
Nuevo México	16.06	20.87

S.D.= Standard Deviation

It is possible to notice in the Table 5 that the highest levels of mercury in urine from women are found in communities of Monkey Town and Nuevo Mexico. As already mentioned, these communities have the highest concentration of Processing Centers in the Block B and houses were built very close to the mills.

Based on variance analysis (ANOVA) it was **not** found significant difference among the averages of mercury concentration in urine from women living in different communities ($p = 0.318$).

No correlation was found between Hg concentrations in female urine and the distances from their houses to the Processing Centers ($r = 0.047$).

Mercury in Urine from Children

The average concentration of total Hg in urine of children from the communities around the Processing Centers is 33.30 with standard deviation of 70.80 µg Hg/g creatinine. As in the previous groups, the results show high variability as a result of differences in living and working habits of the children. About 53% of the 62 children sampled had Hg concentration in urine above the ***alert*** level and 14.5% above the ***action*** level. As also seen in Fig. 6, **about 10% of the sampled**

children had levels of mercury in urine above 100 µg/g creatinine in which neurological symptoms of intoxication should be observed.

In few cases it was observed the direct participation of children in the mining and processing activities. It is very likely that these kids work voluntarily to help their parents and relatives as already mentioned in a study carried out by the International Labor Organization on child labor in artisanal mining in Venezuela[19].

About 32 % of the urine samples from children have shown Hg concentrations below the detection limit of the method (0.2 µg/L). In the community of Nuevo Mexico, 84% of the urine samples was above the ***action*** level (20 µg Hg/g creatinine). In this site, Hg concentration as high as 320 µg Hg/g creatinine was analyzed in a 7 year-old boy. In Monkey Town, 25 % of the samples had Hg concentrations above the ***action*** level, and the maximum Hg concentration was found in the urine of a 13 year-old girl (384 µg Hg/g creatinine). In the community of Chile, 67 % of the urine samples had levels of mercury below the detection limit of the analytical method and only two samples had concentrations above the ***alert*** level (5 µg Hg/g creatinine).

Table 6 - Average of Total Mercury in Urine Samples from Children
(µg Hg/g creatinine)

Community	Average	S.D.
Monkey Town	30.97	79.95
La Fábrica	34.13	51.64
Chile	2.35	4.29
Nuevo México	60.06	83.18

S.D..= Standard Deviation

No correlation was found between concentration of total mercury in urine from children and the distance between their residences and the Processing Centers (r = - 0,189).

Symptoms of Occupational Exposure of Miners and Millers

The occupational exposure of miners and millers was also investigated based on subjective and objectives symptoms obtained in the interviews and medical exams. This group is constantly exposed to mercury vapors when burning amalgams and handling copper-amalgamating plates. Figure 7 shows some symptoms typically associated with:

- chronic exposure at very high levels of mercury,
- acute intoxication or high exposure for short term to mercury vapors,
- long term exposure at low levels of mercury vapors and
- long term exposure at high levels of mercury vapors.

Despite the direct contact with mercury of both groups, miners and millers, the symptoms are slightly more evident in miners (Fig. 7). As mentioned before, the differences in working habits between miners and millers are not significant. The correlation between symptoms reported by the individuals (also known as “subjective symptoms”) plus observed (“objective”) symptoms and Hg in urine of miners and millers, have shown stronger correlation in the group of millers (Table 7). In the miners’ group, the linear correlation coefficients were below 0.5 indicating poorer correlation between symptoms and levels of Hg in urine than in the case of millers.

[19] Bermúdez, D., 1999. La pequeña Minería en Venezuela. Trabajo presentado a la Oficina Internacional del Trabajo (OIT) en el marco del programa IEPC-Erradicación Internacional del Trabajo Infantil, Lima, Perú. (In Spanish).

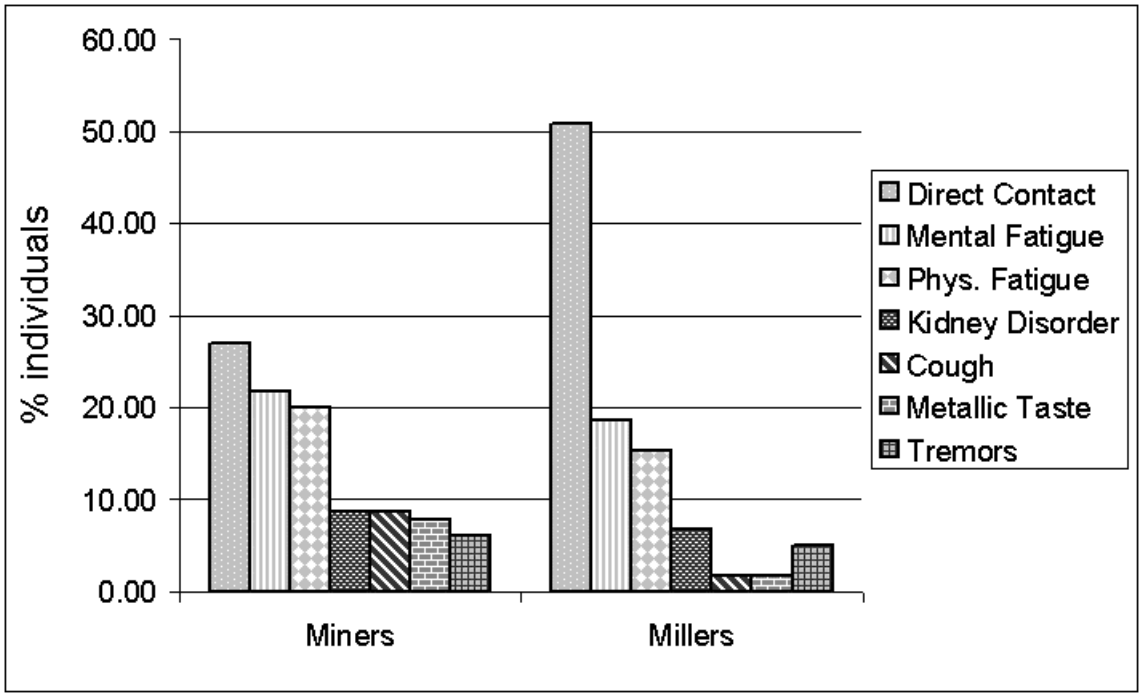


Fig. 7 - Symptoms in Miners and Millers

Table 7 – Correlation between Symptoms and Hg in Urine
(r = linear correlation coefficient)

Symptoms	**r (Miners)**	**r (Millers)**
Mental Fatigue(*)	0.48	0.65
Physical Fatigue(*)	0.35	0.60
Kidney Disorder(*)	0.34	0.08
Cough(*)	0.08	0.71
Metallic Taste(*)	0.02	0.42
Tremors(o)	0.03	0.51

Note: (*)reported by the patient; (o)observed during medical exam.

Symptoms of Occupational Exposure of Women

It was noticed a number (21% of the group) of women with occasional direct contact with mercury. Most women with direct contact with Hg are located in the communities of Monkey Town and Chile. In these cases, women are sporadically involved in the amalgamation/amalgam burning process. The reported symptoms of mercury intoxication were investigated in the women group and more than 40% and 20% of the interviewees complained about mental and physical fatigue respectively (Fig. 8). Most individuals did not show relevant symptoms that can be correlated with Hg intoxication, but some women directly involved with amalgamation/burning claimed that they feel metallic taste and muscular tremors were observed during the medical exam..

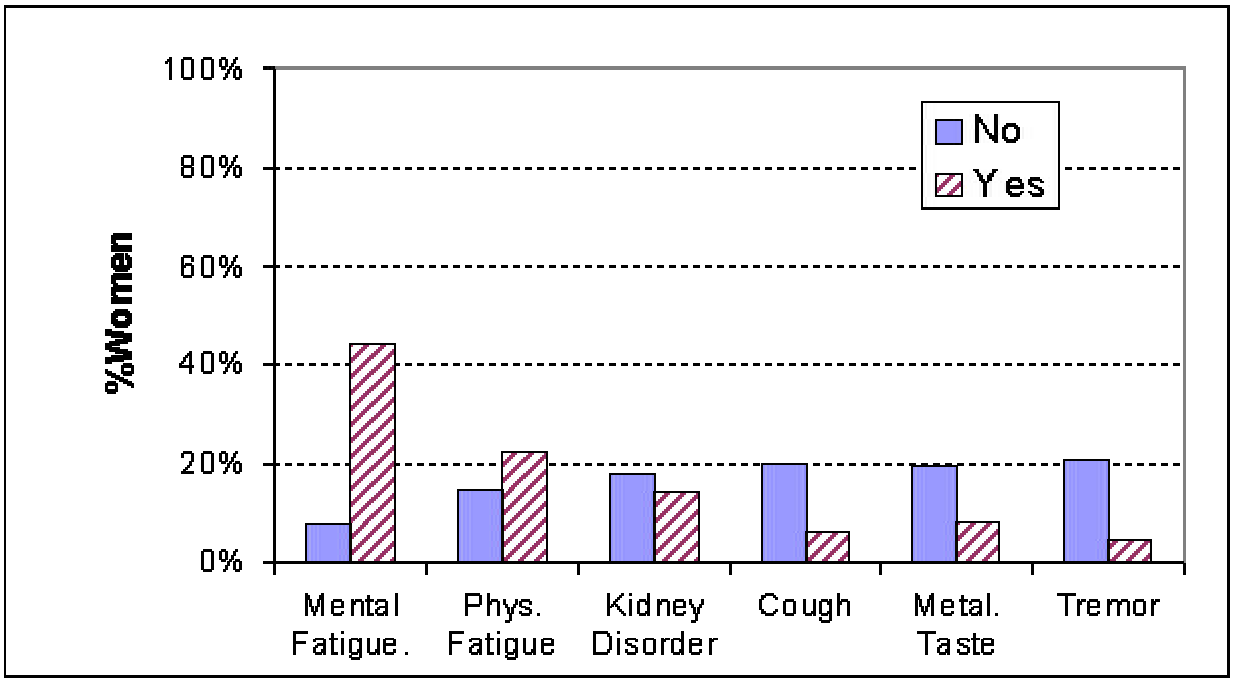


Fig. 8 - Intoxication Symptoms in Women

Results of the clinical-neurological exams

From the individuals submitted to the clinical-neurological exam (questionnaire 3), six were removed, as four had suffered cranial traumatism, one had diabetes and one had a history of exposure to toxic substances used in agriculture. The neurological signs of mercury intoxication found in three groups (women + children, miners and millers) were walking ataxia, hand tremors, eye tremors, incapability of performing the finger-nose test, dysdiadochokinesia, patellar and hyper-reflexia, and patellar and cubital hypo-reflexia. Eye tremor is an easy and characteristic symptom to be evaluated.

In 25% of women and children, it was possible to identify objective symptoms or abnormal behavior during the exams, but just 28% of the miners and millers have shown objective symptoms. The difference in observed symptoms between the examined groups was not statistically significant, despite the higher levels of mercury in urine of miners and millers when compared with women and children. Regarding the statistical analysis, it was considered as a positive symptom all cases in which at least one or more objective symptoms were identified. In chronic intoxication, the individuals are exposed to lower concentrations of the pollutant for long periods of time and if the absorption exceeds excretion, the toxic substance accumulates and the effects of accumulation is perceived as subtle alterations of the neuropsychological and neurobehavioral functions. Sub-clinical alterations are more difficult to diagnose in a normal clinical evaluation and this is the most classical and usual effect of mercury on the nervous system.

Specific neuropsychological tests

It was used a scoring process suggested in the UNIDO Protocols (Veiga and Baker, op. cit.) to express the results of the neuropsychological tests. Just three groups were evaluated: millers, miners and women. This latter were those not directly involved in the amalgamation process. The scoring process ranged from 0 to 3. Score 0 (zero) means good performance in the test and score 3 indicates highly poor performance; the higher the punctuation, the greater the function deficiency[20].

[20] Score: WMS (0 = 0, 1-2 =1, 2 = 3-4); Match box (0 = 0-15 seconds; 1 = 16-20 seconds ; 2 = 21 seconds or more); Finger-Tapping (0 = 65 or more dots, 1 = 54 to 64 dots, 2 = 0-53 dots); Frostig (0 = 13 to 16 correct answers, 1 = 10 to

The Wechsler Memory Scale (WMS) test evaluates recent memory. The test involves a procedure to ask the patient to repeat a list of numbers that ranges from 4 to 8 single numbers. The results have shown that about 23% of miners and 10.5% of millers had scores 2 (indicating deficiency) whereas just 9.4% of women had this score. It is clear by Fig. 9 that just about 34.3% of miners and 26% of millers had score zero (no problem) and almost 44% of the women did not show any memory problem.

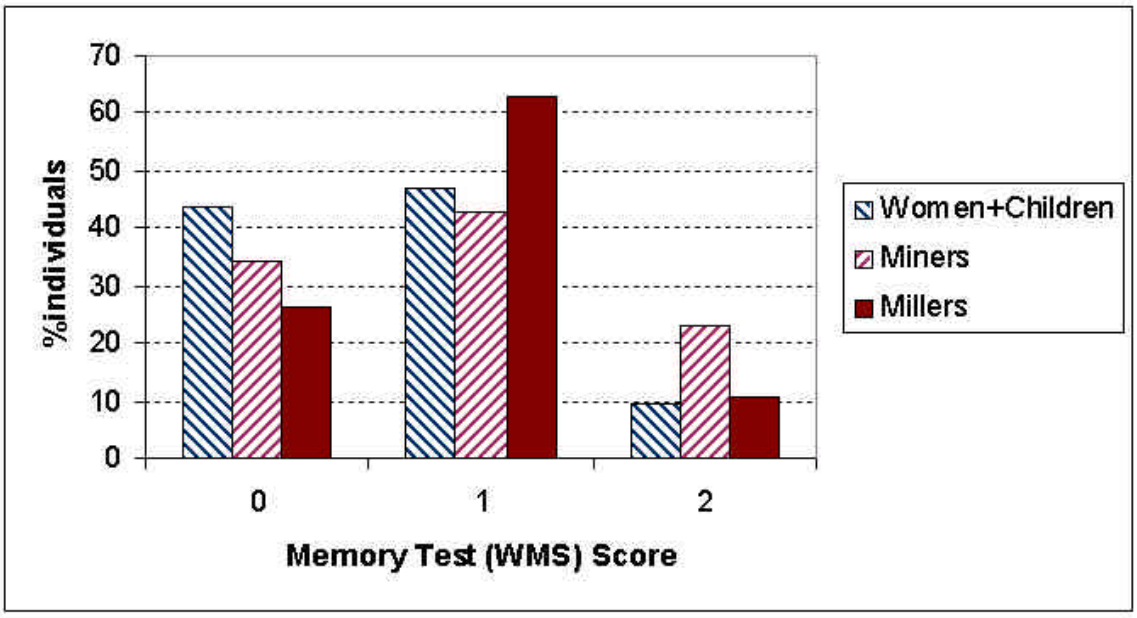


Fig. 9 - Results of Memory Test (WMS)

The Match Box test evaluates coordination, intentional tremor and concentration. The test consists in putting 20 matches on a table, half of them on each side of an open matchbox, and the individual must put all matches into the box using left and right hand alternatively. The time is measured. About 15 seconds is considered a normal time for this task. Miners and millers performed better than women (Fig. 10) but the millers performed worse than miners.

The MOT Test (Finger-Tapping) evaluates spatial perception, fine motor coordination and normal dexterity. The test consists in asking the volunteer to keep his/her elbows on the table and make as many points as possible on a piece of paper with a pencil. The number of points is counted after 10 seconds. A normal individual can easily make more than 65 points. Miners and millers had more difficulties in performing this test than women (score 1) (Fig. 11).

12 correct answers, 2 = 0 to 9 correct answers); Episodic Memory (0 = 3 correct answers, 1 = 2 correct answers, 2 = 1 correct answer, 3 = wrong answers).

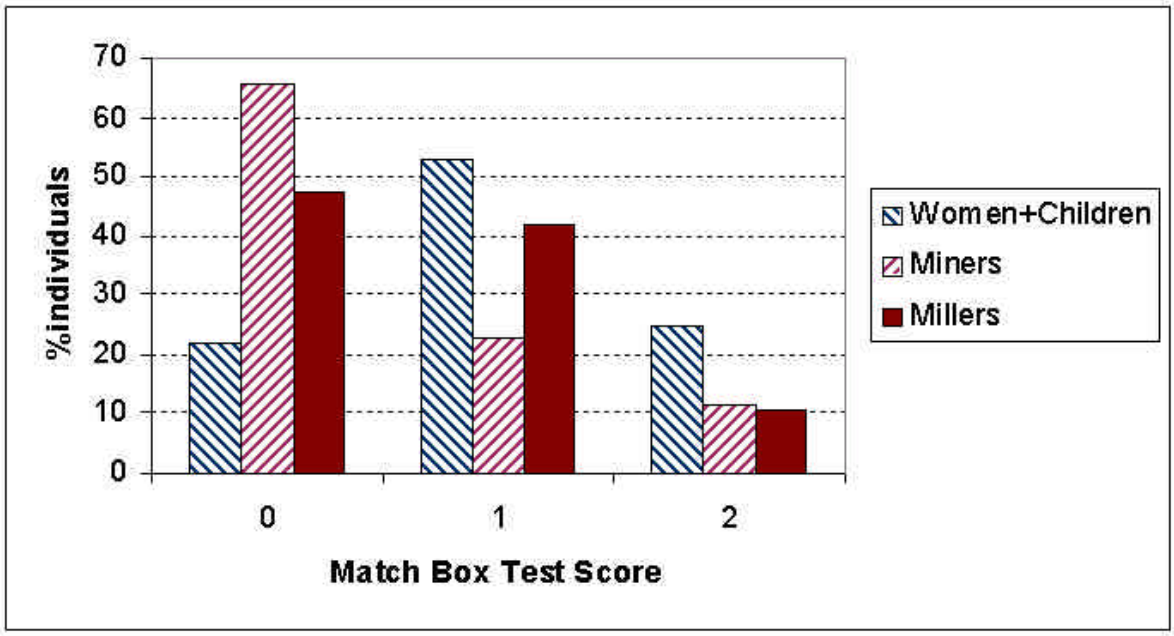


Fig. 10 – Results of Match Box Test

The Frostig test evaluates visual perception. It consists in drawing a line from one point to another between a narrow gap. The results did not show good sensibility in measuring neurological effects, as almost 100% of all tested individuals could perform the tasks without any visible problem. The only exception was a miller, who has evident serious chronic intoxication by metallic mercury.

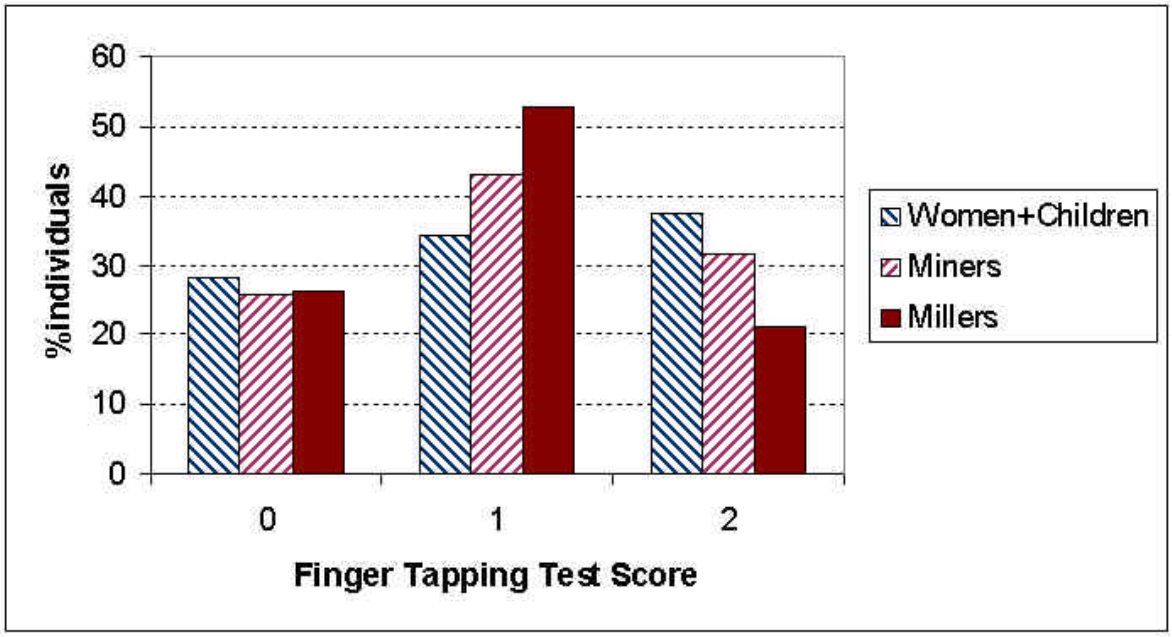


Fig. 11 – Results of Finger-Tapping Test

In the test that estimates episodic memory, no women have shown score 2 or 3 (deficiencies), but almost 14% of miners and 11% of millers have shown scores above 2 (Fig.12). The tests that evaluate episodic memory are similar to the Mini-Mental State Examination tests. This evaluates memory, orientation, ability to calculate and speak. This is probably one of the most used and studied tests for quick evaluation of neurological functions. This test has been quantified and

adjusted to different ages and instruction degree. Its application is simple, and this test can also be applied to illiterates[21]. A score 2 in this test is a clear indication of a neurological problem.

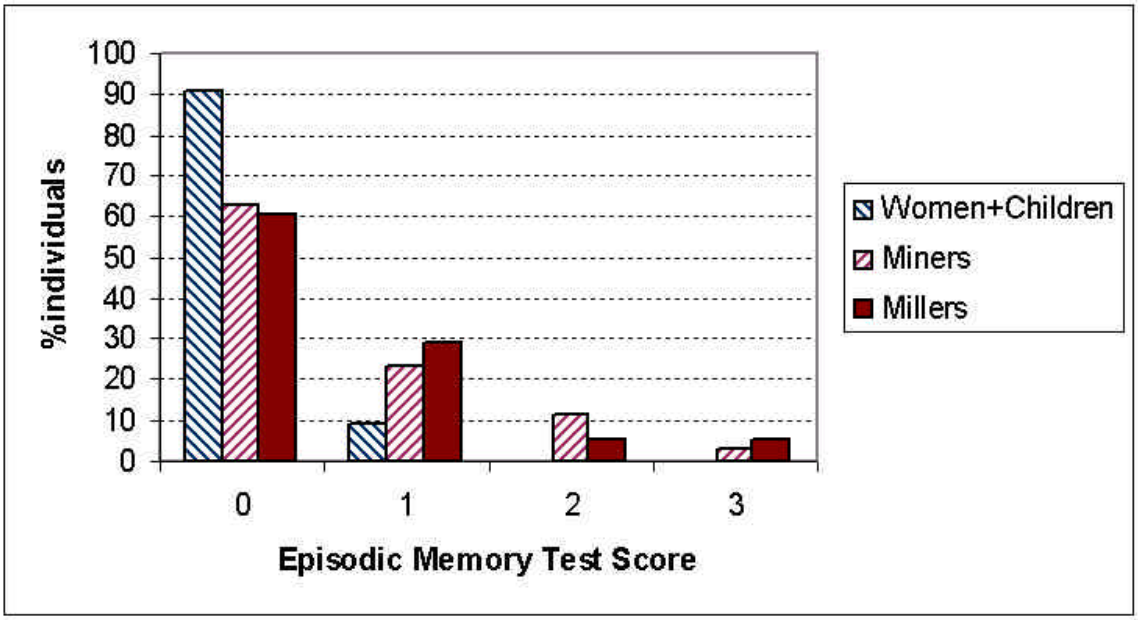


Fig. 12 – Results of Episodic Memory Test

When the scores of neuropsychological tests were correlated with Hg levels in urine, it was possible to notice that individuals with high mercury concentrations in urine (above 50 µg Hg/g creatinine) have shown difficulties (score 1 and 2) to complete the WMS Memory Test (Fig. 13). It is also possible to observe that the percentage of individuals with bad performance (score >1) reaches 76.5% for individuals with Hg in urine above 50 µg/g creatinine. Similar situation was observed in the Finger-Tapping Test (Fig. 14). The Match Box Test (Fig. 15) could not highlight a good correlation between Hg levels in urine and test performance but the Episodic Memory Test (Mini-Mental) was very useful to show that the % of individuals with score zero (no problem) decreases when the Hg level in urine increases. In addition, the % of individuals with poor performance in this simple test (score 1, 2 and 3) increases with the level of Hg in urine (Fig. 16). This is a strong indication of alteration of the neurological functions by mercury vapor intoxication.

About 27% of individuals who performed the specific neuropsychological tests have noticeable neurological problems detected in the clinical exams. However, no significant correlation was found between the results of the medical exams and the speficic tests, except a slightly increase of scores 2 and 3 from individuals with noticeable clinical-neurological problems (symptoms) (Fig. 17).

The tests that estimate coordination and manual dexterity (drawing figures) do not have specific scoring system in the UNIDO Protocols. This normally evaluates patients with significant central neurological lesions. In this study it was adopted similar scoring process as the mini-mental tests, i.e. ranging from 0 (no problem) to 3 (deficient). The percentage of miners and millers with score above 2 was, 52.2% and 34.8% respectively which is a clear demonstration of poor performance (problems).

[21] Bertolucci, P. H. F.; Brucki, S. M. D.; Campacci, S. R.; Juliano, Y., 1994. O Mini-exame do Estado Mental em uma População geral. Impacto da Escolaridade. *Arquivos de Neuropsiquiatria*, v.52, p. 1-7 (in Portuguese).

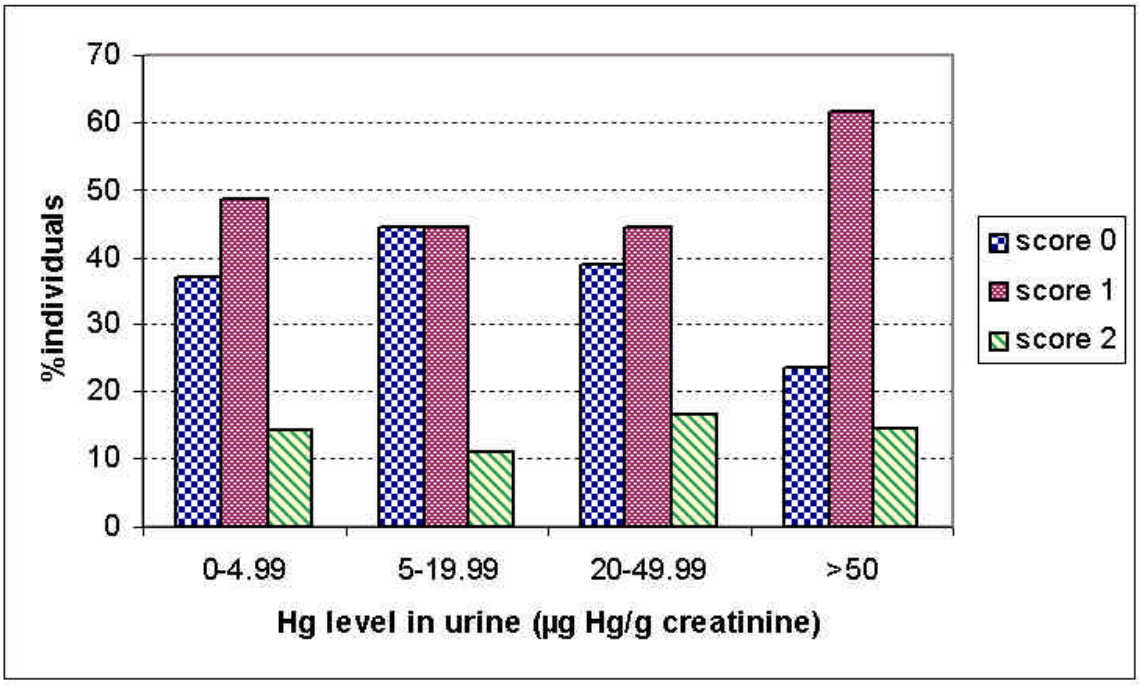


Fig. 13 – Relationship between Hg in Urine and Memory Test (WMS)

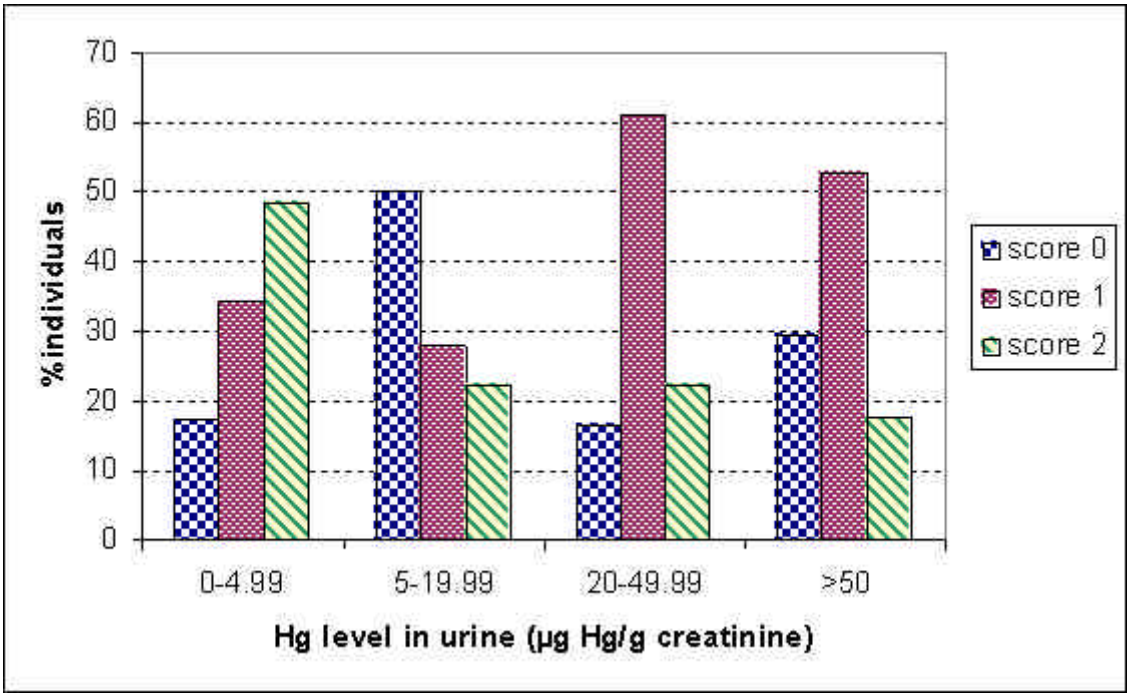


Fig. 14 – Relationship between Hg in Urine and Finger-Tapping Test

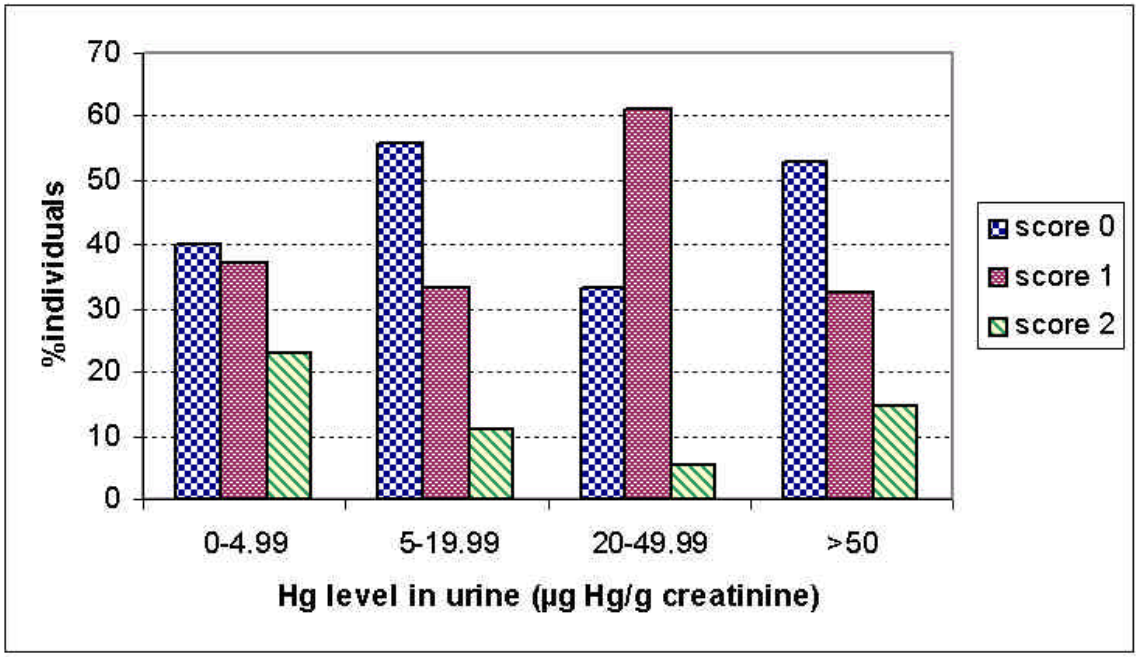


Fig. 15 – Relationship between Hg in Urine and Match Box Test

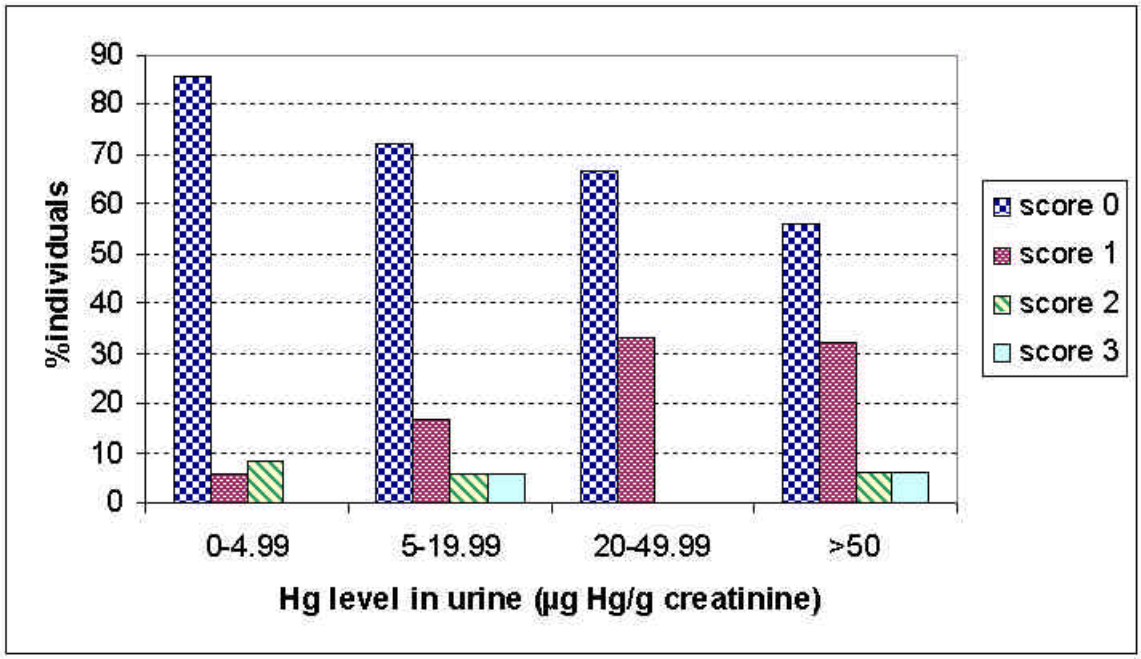


Fig. 16 – Relationship between Hg in Urine and Episodic Memory Test

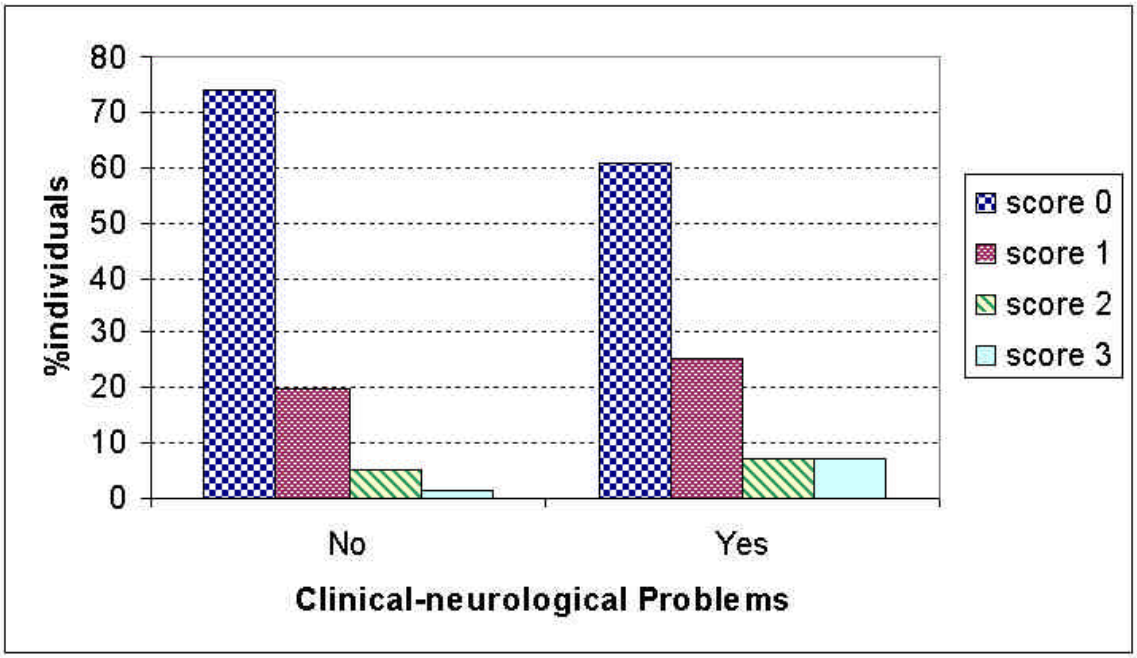


Fig. 17 –Observed Problems in the Clinical neurological Exam
and Score of the Episodic Memory Test

DEMONSTRATION OF CLEANER TECHNOLOGIES

Extracting Gold and Mercury from Tailing

As part of the fieldwork, some simple techniques were brought to the miner's attention in order to reduce mercury emissions and exposure while decomposing amalgams. A Processing Center ("El Mago") was rented to conduct tests and demonstrate cleaner technologies of gold processing to the local artisanal miners. Five tests were conducted using tailings from the Processing Center pond. Extraction of residual gold from tailing was in fact advantageous as this material was more homogeneous than the primary ores. In addition this called attention of miners and millers as gold in tailings is usually unliberated or very fine and the workers are aware that they do not have methods to extract it. Ultimately, this is the gold just extracted by the "company's methods". Most tests were conducted using a sluice box with the four-special-amalgamating Goldtech plates. These plates are manufactured in Brazil and a Venezuelan company, PARECA, sells the plates in Puerto Ordaz, Venezuela (US$ 200 per 40x30 cm plate). This special plate has a thin coating of Hg and Ag electrolytically deposited onto a copper plate. Mercury from tailings and eventually gold is captured and firmly fixed to the plate surface. Mercury losses are minimized. When the plates are fully loaded, amalgam is removed by washing with a plastic scraper. This kind of plates was used successfully in Brazil to remove mercury from contaminated tailing but they can also be used to amalgamate gravity concentrates. The support for four plates was made of wood in Venezuela. The configuration was set up to allow a cascade effect from one level to another. Another wood structure was built to hold the four Goldtech 40 x 30 cm plates placed in zigzag, as seen in the Fig. 18. This allows reduction of the flow speed on each plate and rendered better results.

The Goldtech plates were activated with vinegar before receiving Hg-contaminated tailings. Initially, tailings collected in the ponds were passed on the Goldtech plates and miners could see a large amount of mercury droplets retained on the surface (shining dots). Then, the Goldtech plates received a bit of mercury (5g/plate) and about 1100 kg of tailings were fed to the hammer mill and consequently on the plates. Samples before and after feeding the Goldtech plates were systematically collected every 15 minutes and the whole material was dried, pulverized,

homogenized and analyzed in triplicate using LUMEX atomic absorption spectrometer (Table 8). The material before entering the Goldtech plates analyzed 62.2 mg/kg of Hg and left the plates with 3.24 mg/kg Hg in average. More than 95% of Hg was removed from the tailings. However, the gold recovery process was not so efficient. Before entering the Goldtech plates, the tailings had in average 9.53 g Au/tonne. The final tailing, after leaving the Goldtech plates, analyzed 9.05 g Au/tonne. Just 0.7 g of gold was recovered from the plates. This is a clear indication of lack of liberation of gold from the silicates.

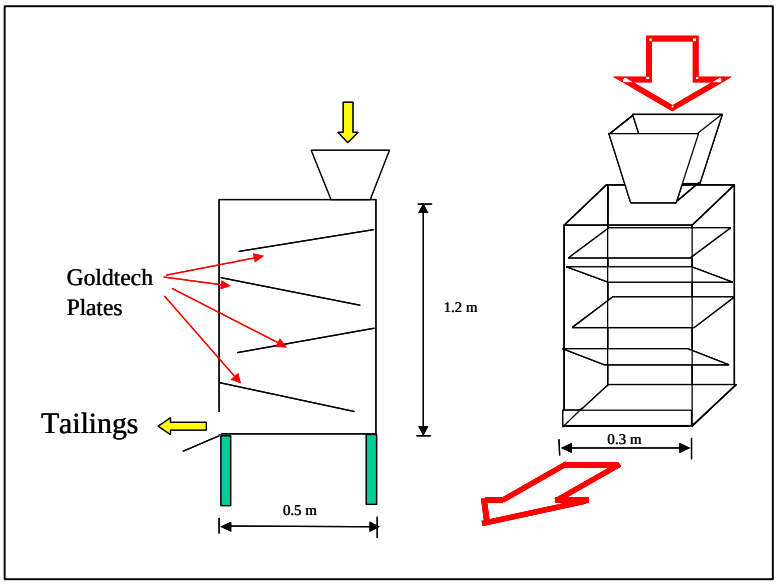


Fig. 18 –Special-Amalgamating Plates (Zigzag)

Table 8 – Hg (mg/kg) in Samples before and after Treatment with Goldtech Plates

subsample:	A	B	C	**Ave**
Before Goldtech plates	64.3	59.4	62.8	**62.2**
After Goldtech plates	2.98	2.93	3.80	**3.24**

Other test was conducted using 1805 kg of tailings to demonstrate to miners and millers the advantages of using carpets to concentrate gold prior to amalgamation. The material fed the hammer mill and discharged on a sluice box lined with two carpets in series. Both carpets were locally acquired: a synthetic grass and a Multiouro Tariscado. This later is produced by the Brazilian company Sommer (subsidiary of the German company Tarkett Sommer) and it is widely used by Brazilian artisanal gold miners. This type of carpet is adequate for gold speck of rice-medium size. This carpet cost in Venezuela around US$ 10 to 15/m² which is cheaper than other types of imported vinyl carpets. The Brazilian carpet, appropriated to retain fine gold, was placed at the beginning of the flow, where the speed is slower. Visibly, the Brazilian carpet retained more gold than the synthetic grass.

The concentrates from the carpets were washed and amalgamated on the Goldtech plates. This operation was done cleaning the carpets with water and directing the pulp of concentrates to the plates placed in the zigzag structure. The gravity concentrate was re-passed three times on the plates. After retorting, 1.3 g of gold was obtained. Systematic analyses of final tailings of this test revealed an average grade of 3.75 g Au/tonne. The low recovery of gold is definitely due to lack of gold liberation.

Another test was set up using Cleangold sluice boxes followed by Goldtech plates. The Cleangold sluice uses polymeric magnetic sheets, with the magnetic poles aliened normal to the direction of

the flow, inserted into a simple aluminum sluice box. Magnetite, a mineral usually found in gold-ore deposits, forms a corduroy-like bed on the sluice floor, which appears effective at recovering fine gold. Fine particles of steel from the hammers are also trapped and form the liner. This sluice box can be available in a variety of sizes and a 2ft x 6in (60x15 cm) sluice costs US$ 75 in USA. The main advantage of this sluice is the high concentration ratio. Gold becomes trapped in a magnetite layer and the sluice can be scrapped and washed into a pan. About 628 kg of tailings were passed in a 2 ft Cleangold sluice box followed by two 8x8in (20x20 cm) sluices and the tailing was directed to the zigzag structure with four Goldtech plates. The Cleangold sluice retained visible mercury droplets and recovered 0.64 g of gold in a concentrate that analyzed 2854 mg/kg Au[22]. The gold recovered by this sluice box was extremely fine. This was demonstrated to the miners and millers. Goldtech plates recovered 0.25g Au. This configuration was capable of recovering 15.4% of the gold from the tailings in which 11% of the gold was recovered using Cleangold sluice and 4.4% of gold in the Goldtech special amalgamating plates.

Using the Cleangold sluices it was also possible to pan the concentrate and, using a plastic vial, gold was sucked from the concentrate. Gold was visibly very fine in the concentrate. Other tests were conducted with primary ores using Cleangold sluices and Goldtech plates to satisfy the miners who were interested to test these "new" techniques.

All results have reinforced the conclusion that lack of gold liberation is the main obstacle to increase gold recovery in El Callao. The use of hammer mills to re-grind tailing samples does not bring any benefit in terms of increasing gold liberation. This is the main reason for gold loss in the Processing Centers and high recovery in the CVG-Minerven cyanidation plant, since the mining company uses ball mills to re-grind the tailings at least below 200 mesh (0.074 mm).

The only possibility to increase gold recovery in the Processing Centers is using small ball mills (e.g. ∅48x60 cm) to reduce the size of the ground product and promote gold liberation. As gold is very fine, it seems that the Cleangold is an appropriate and affordable technology for the miners and millers to process primary ores via gravity concentration. It seems that soon or later the Processing Centers, as in Zimbabwe, will adopt cyanidation to extract residual gold from tailings. In this case, the environmental problem will be exacerbated, as the mercury will become partially soluble in the final tailings and therefore available for the methylating agents. Intervention of the Government authorities and/or CVG-Minerven to educate and provide assistance to the miners is badly needed otherwise the cyanidation process will be implemented and, without any environmental and health concern, the results will be catastrophic.

Retorts

It was revealed by the UNIDO medical team that the level of mercury intoxication of the miners in El Callao is **one of the highest in the world**. The use of retorts to reduce occupational exposure is paramount. Miners burn amalgams in shovels and, usually, very near their noses, where they can see better the decomposition process. Very few miners and millers believe that this is a problem and they keep burning mercury carelessly. Some millers leave retorts available for miners but they remove the top of the retort and use it as an open-air crucible to burn and melt gold. In many cases this operation is conducted in a confined environment.

Using LUMEX spectrometer, mercury in the breath of miners and residents was analyzed. The normal level of mercury in the breath depends on the number of amalgam-dental fillings of each individual as well as the level of mercury in the environment. This is usually below 100 ng/m³. It is also known that just 7% of the mercury vapor dose received by an individual is released during

[22] Gold analyses were conducted at CVG-Minerven using fire assay method

respiration[23]. In El Callao, miners usually have shown 10,000 ng/m³ of mercury in their breath. Kids, living near or in Processing Centers, had as much as 5,000 ng/m³ of mercury in the exhaled air. Despite of the rudimentary procedure adopted to analyze breath of volunteers, this was effective to call attention of the people working in the Centers or living around them to the high levels of mercury they have been exposed and accumulated in their lungs. This simple analysis has also contributed to convince the miners and millers to watch the demonstration of different types of retorts made by UNIDO in Venezuela.

In order to introduce retorts to miners, four different types of retorts were locally manufactured and the principle of retorting was demonstrated using Thermex glass retort. The retorts were fabricated in a metal shop in El Callao using crucibles of stainless steel. The crucibles were actually small stainless steel salad or sauce bowls acquired in kitchen stores in Puerto Ordaz. A RHYP retort made of galvanized water connection tubes was also built and tested. All retorts were demonstrated to miners and amalgam was burned using a propane torch as usually they use to burn amalgams in shovels. The burning process took in average 15 to 20 minutes.

One of the most appreciated retorts was that fabricated using the concept of the fish-tin retort used in China. This was a more elaborated retort built on a steel table but also using a stainless steel salad bowl as crucible. A steel cover (bucket) was placed on the crucible. The table was filled with water and the amalgam burned with a blowtorch from the bottom. As the crucible wall was thin, the retorting time was short. Mercury condensed on the wall of the cover and dripped into the water. The manufacturing cost of this prototype was around US$ 80 but this could be drastically reduced. This retort took 10 to 15 minutes to eliminate most mercury from amalgam using a propane blowtorch. A serious inconvenient of this, and other retorts, is that miners can remove the cover (bucket) from the crucible while the retort is still hot. When this occurs, miners are exposed to mercury vapor. This was demonstrated in 1995 when a graduate student[24] from UNEG – Universidad Experimental de Guyana, analyzed urine of 20 amalgamation workers using retorts and noticed that 8 individuals had high mercury levels in urine because they use to open retorts before cooling them. This was shown to miners and millers and it was advised to refrigerate the covers pouring water on it and wait some minutes before opening the system.

TECHNOLOGY TRANSFER IN CHEMICAL ANALYSIS

Analytical techniques were discussed and transferred to the chemical laboratory of the La Salle Foundation in San Felix, Ciudad Guayana. The methodologies for quantitative and semi-quantitative analyses of total mercury were demonstrated to the technicians. This laboratory has two instruments to analyze total Hg. One is a GBC, Model Avanta 3000 atomic absorption spectrometer that uses a hydride generator to extract Hg from digested samples. When UNIDO team was in Venezuela, this equipment was not operational. The second instrument is a Bacharach MAS50D atomic absorption, which is a cold vapor atomic absorption spectrometer dedicated to analyze mercury. This equipment seems to be inadequate to analyze urine as it requires a large volume of sample, about 100 mL. As most of the collected samples have volumes below 50 mL, the only possibility to use the equipment is by diluting the samples. For highly concentrated samples, this procedure is feasible, but the detection limit is then reduced for diluted samples.

[23] Pogarev, S.E.; Ryzhov, V.; Mashyanov, N.; Sholupov, S.; Zharskaya, V., 2002. Direct Measurement of Mercury Content of Exhaled Air: A New Approach for Determination of the Mercury Dose Received. *Analytical and Bioanalytical* Chemistry, 374, p. 1039-1044.

[24] Schulz-Garban, K., 1995. Determination of Hg Concentration in Workers and in the Air of Several Amalgamation and Gold Processing Centers of "Bajo" Caroni, June-Novembre 1994. Master Thesis, UNEG, Ciudad Guayana. 156p. (in Spanish)

The quantitative analysis of mercury discussed with local technicians was based on the procedure of Akagi (1994)[25], from the National Institute of Minamata Disease, Japan. The method consists of adding 1 to 5 mL of urine drop wise, while stirring, into a 50 mL volumetric flask containing a mixture of 1 mL of nitric acid, 1 mL of perchloric acid, 5 mL of sulphuric acid and 1 mL of water. The mixture is heated to 230-250 °C for 20 minutes and after cooling the solution is completed to 50 mL with water. The Hg(II) in solution is then reduced to gaseous elemental mercury with stannous sulfate (or chloride) 10% in a solution of HCl 1N. The Hg° (g) is carried by air (in this case) into the cell of the cold-vapor atomic fluorescence spectrometer (CVAFS) for detection at wavelength of 253.7 nm.

For the semi-quantitative analysis, it was transferred a simple methodology of heating samples of soil and sediments over 600°C in a glass test tube. All forms of mercury evaporate and are carried into a solution of sulfuric acid with potassium permanganate (Appendix 4). In the sequence, mercury is extracted with a solution of dithizone with chloroform and the resulting dithizoate of mercury, with red-orange coloration, is compared with colorimetric standards previously prepared or analyzed in a spectrophotometer.

In order to test the semi-quantitative procedure, four samples of sediments, previously analyzed by atomic absorption by La Salle, were tested. The results in the Table 9 confirm the efficiency and precision of the semi-quantitative method. The method can be applied to biota samples as well.

Table 9 – Results of Semi-quantitative Analyses of Sediments

Sample	Hg known (ppm)	Hg found (ppm)	Duplicate (ppm)
A	0.8	0.5 to 1.0	0.5 to 1.0
B	1.5	1.0 to 2.0	1.0 to 2.0
C	1.9	1.0 to 2.0	1.0 to 2.0
D	2.5	2.0 to 3.0	2.0 to 3.0

Using these methods the local laboratory will be able to conduct “in situ” analyses creating possibilities for constant monitoring of mercury levels in biological and geochemical samples.

WORKSHOP IN EL CALLAO

A two-day workshop was conducted in El Callao on December 8 and 9, 2003. The first day was used to attract the miners and millers to the El Mago Processing Center where UNIDO team set up a series of practical demonstrations. It was manufactured T-shirts with UNIDO, Minerven, HECLA and CVG logos and the sentence (in Spanish): “*For you health and your son’s health...Recycle Mercury...Use Retorts*”. A banner with this sentence was also produced and displayed on the premises. The demonstration day started explaining the principles of the sluice boxes (carpets and Cleangold) to concentrate gold without using amalgamating Cu-plates. It was explained the environmental problems related to amalgamation of the whole ground ore and how much mercury has been lost. It was demonstrated the use of the zigzag-Goldtech plates and the advantages of using such a system to clean up tailings and amalgamate gravity concentrates. It was stressed the problem related to lack of liberation of gold from the ore and the limitations of the hammer mills to grind finer that 1 or 0.5 mm. It was mentioned that they are recovering likely less than 30% of the gold and losing money with energy, hammers and mercury. All numbers found in the UNIDO preliminary processing tests with tailings were presented to the miners. A system of charging for charging based on ore hardness was suggested to the Processing Center’s owners. A primary ore

[25] Akagi, H., 1994. Exposure Assessment. *In*: Proc. of the International Workshop on Environmental Mercury Pollution and Its Health Effects in Amazon River Basin. p. 118-125. Rio de Janeiro, Nov. 30, Dec 2, 1994. Ed. National Institute of Minamata Disease, Japan and Instituto de Biofísica, Univ. Federal Rio de Janeiro, Brazil.

and tailings were processed together with the miners using the Cleangold sluices as the main concentration device and Goldtech plates as a scavenger of the Au and Hg in the tailings. The gold concentrate was washed and panned in front of the miners. A clear layer of yellow gold was shown to the miners. Using a plastic sucker, gold was removed from the pan and no Hg was used.

Using the Goldtech plates after the Cleangold sluice it was possible to show to the miners the how residual Hg (and Au) can be recovered from tailings. The amalgam was removed from the plates and retorted.

Five different types of retorts were used in front of the miners and millers to retort all amalgam beads obtained during the tests conducted in the Center in that week. Miners showed interest in a retort made by a local manufacturer, Mr. Rafael "Colombiano" using the model of the Chinese fish-tin retort. The idea of using salad bowls as crucibles of most of the retorts fabricated by the metal shops was very appreciated by the miners/millers as gold comes out yellow after retorting.

In the second day of workshop, a meeting with various stakeholders occurred at the CVG-Minerven Union House (Negra Isidora), in El Callao. With about 50 people (miners, millers, residents, Government representatives, CVG representatives, etc.) all members of the UNIDO project presented partial results of the fieldwork. Mr. Gilberto Berrios from HECLA, presented his data from the socio-demographic study at the Block B. Mr. Dario Bermudez, on behalf of the health survey team, has shown the results of urine analysis and clinical exams.

The presentation of the technical results of the processing and amalgamation tests was conducted by Mr. Marcello Veiga who called the attention of the audience for the high levels of mercury being emitted by miners and millers. It was also highlighted the economic inefficiency of the Processing Centers and the solution for this rely on a better relationship miner-miller to improve production methods.

Ms. Monika Roeser from UNIDO headquarters in Vienna stressed the objectives of this preparatory mission and agreed to establish a strategy together with CVG, HECLA, Association of Miners and other stakeholders to introduce a more sustainable project in the region where cleaner technologies can be further demonstrated, a strong awareness campaign can be conducted, environmental impacts can be evaluated and simple analytical methods for monitoring mercury intoxication can be brought to the local authorities.

CVG representatives have reinforced the words of UNIDO representative and called the attention of the audience to the seriousness of the situation in El Callao. They promise to make all efforts to establish a future program with UNIDO to educate miners and surrounding communities as well as introduce cleaner technologies in the area.

RECOMMENDATIONS

The medical exams, the urine analyses and the specific neuropsychological tests have revealed that millers and miners have shown symptoms that suggest serious mercury intoxication. In just one worker it was characterized acute mercury intoxication and it was recommended to the local doctors and nurses to follow up this case. This was also communicated to the individual and recommended his immediate removal from the polluting source for treatment. The specific neuropsychological tests have highlighted deficit of the cognitive functions of some workers such as alteration of the visual perception, deficiency of the recent and episodic memory, as well as deficiency of the spatial perception, motor coordination and manual dexterity. The cognitive deficiency showed positive correlation with the levels of total mercury in urine and this is more prominent in Hg concentrations above 6µg/Hg/g creatinine. Some of the neuropsychological tests have revealed that people not

directly involved in the amalgamation work but living near the Processing Centers have been neurologically affected by mercury vapors. The alterations found in the medical exams and neuropsychological tests of people indirectly exposed to mercury vapors claim for immediate action to reduce emissions and reduce exposure of innocent people to the pollutant.

It is suggested:

- immediate removal of children from the polluting source (many children play and work in the Processing Centers)
- continuation of the monitoring of cognitive aspects of the residents of Block B, in particular children from age between 7 and 12,
- training of local health workers to be able of monitoring health conditions as well as performing the specific neuropsychological tests in residents,
- implement an interdisciplinary strategy to educate workers and residents to reduce and avoid mercury vapor exposure.

Processing Centers are usually a good idea to avoid spreading environmental impacts caused by artisanal gold miners, but at the same time, when not well conducted, this concentrates the contamination in certain sites. The technologies used by the Processing Centers in El Callao are exposing miners, millers and surrounding communities to high levels of mercury vapor. The technique of using hammer mills associated with amalgamating copper plates is recovering, at the most, 30% of the gold in the ore. As gold in El Callao seems to occur at fine grain size, a more efficient grinding process is needed. This must be associated with a gravity separation process that does not use mercury. The amalgamation of the whole ground ore using copper-plates, as extensively used in El Callao, is an ancient inefficient technology that releases mercury to the tailings and exposes operators to high levels of mercury vapor. There are many concentration techniques that do not require mercury in the processing, such as sluice boxes using appropriate carpets, Cleangold sluices, centrifuges, etc. Amalgamation can still be used as it is simple and cheap, but just a small amount of mercury is needed to amalgamate gravity concentrates. This keeps the mercury use under control and reduces drastically emissions.

The use of retorts is another critical issue in El Callao. Miners and millers do not believe in mercury pollution and keep burning amalgams in pans and shovels. In many cases this is conducted in a close environment. Companies and Government should establish urgently an awareness campaign to introduce safer procedures for amalgam decomposition, such as retorts. ANY RETORT IS BETTER THAN NOTHING. Different types of retorts should be brought to the miners' attention.

In terms of the business, the Processing Centers are clearly using a wrong strategy. As they charge 10% of the gold production and the miners do not know how much gold they mined, the millers very frequently do not produce enough gold to pay their operating costs which is 0.24 and 0.5 g Au/bag for soft ore and hard ore respectively. The method used in Zimbabwe for Custom Processing Centers seems to be more adequate, since the price for processing ore is fixed based on hours of grinding. Definitely a better arrangement between miners and millers must be established in El Callao. .

The business relationship between mining companies and miners/millers must be carefully revisited and improved. As the companies, in particular CVG-Minerven, are acquiring gold-rich tailings from miners this can create future problems for the company as the benefits become concentrated in the company and Processing Centers' owners. The relationship between companies and miners/millers can rapidly deteriorate. The amount of mercury being taking to the companies' environment together with contaminated tailings is considerable and this is definitely contaminating employees (especially those working in the gold melting) and tailing ponds. As mining companies do not purchase tailings (and sometimes ore) with less than 6 g Au/tonne, it is also foreseen that millers

(Processing Center owners) will soon start their own cyanidation plants. Cyanidation of amalgamation tailings, as seen in many other countries, exacerbates the danger of mercury in the environment and facilitates the mercury methylation. This is a problem that soon will come to El Callao and need immediate attention from the authorities.

As yet, there is no educational program for miners/millers, residents and general population to make them aware of the dangers caused by mercury. No consistent program was implemented in the region to bring simple solutions for miners and millers such as the use of retorts to protect themselves and the surrounding population. There are reliable local equipment manufacturers with good technical capacity to develop simple types of equipment suitable for small-scale miners. These manufacturers could be trained to produce better pieces of equipment. Mercury pollution cannot be reduced if the miners/millers do not see any additional benefit in terms of gold production.

All action should take into consideration the realm of problems associated with poverty and rudimentary living and working conditions of the people of Block B. UNIDO has been implementing Transportable Demonstration Units in six countries in Africa, Asia and South America to bring hands-on training to miners/millers and general public. A movable unit consists of a tent to be used as classroom and a container with small pieces of equipment to teach the miners and millers the advantages of using cleaner methods. This brings to the miners and millers' attention a variety of technical options for gold concentration, amalgamation and retorting; it is up to them to select what is affordable, appropriate and durable according to their convenience. The unit also incorporates programs to attract miners and public to watch skits and movies about environmental impacts and mercury pollution highlighting local cultural aspects and incorporating concepts of environmental and health protection. The unit can also bring ideas to improve the livelihood of different mining communities such as suggesting economic diversification activities or value-adding techniques (e.g. handcraft, fish farming, agriculture, brick making using tailings, etc). An initiative like this is badly needed in El Callao and the collaboration of local mining companies is critical to guarantee the sustainability of this program.

APPENDIX 1 – Processing Centers in Block B

Nuevo México

Processing Center	Owner	Number of hammer mills	Number of crushers	Coordinates (UTM)
San Ernesto	Jesús García	5	1	808.511 N 628.978 E
Indoven	David Mejías	4	1	808.491 N 629.272 E
Don Veta	Isidro Betancourt	1 (3 in project)	1	808.574 N 629.333 E
William's Gold	William González	5	1	808.639 N 629.342 E
Oshim	Guillermo Herrera	4	1	808.627 N 629.315 E
Minasoro	Rafael Navarro	3	1	808.579 N 629.690 E
Nueva Esperanza	José Rondón	2	1	808.706 N 629.619 E
Ovimal	Ricardo Rondón	4	1	
El Mago	José Pino	6	2	
Clark Brothers	Roberto Clark	6	1	
El Mamon	Ricardo Rondón	3	1	

La Fábrica

Processing Center	Owner	Number of hammer mills	Number of crushers	Coordinates (UTM)
Nabomar	Ramón Navarro	1 (3 in project)	1	808.420 N 628.722 E
Faremont	Julio Ferrera	4	1	808.426 N 628.845 E

Monkey Town Sector

Processing Center	Owner	Number of hammer mills	Number of crushers	Coordinates (UTM)
Inversiones San Jose	Aníbal Acevedo	4	1	808.273 N 628.183 E
Inversiones Rojas 1	Julio Rojas	4	1	808.305 N 628.104 E
Inversiones Rojas 2	Julio Rojas	3	1	808.294 N 628.049 E
Yuruari	Pedro Anzola	4	1	808.306 N 628.036 E
El Caro	Ramón Alvarado	5	1	808.327 N 628.024 E
Molino Hermanos Ruiz[26]	Nancy Ruiz	3	1	808.171 N 628.716 E
Inversiones Mineras Cuyuni	Leoncio Copeland	3	1	808.440 N 628.125 E
Las Mercedes 1	Ramona Mateo	3	1	808.458 N 628.192 E
Las Mercedes 2	Ramona Mateo	2	1	808.506 N 628.222 E
J. Herrera	Ramona de Herrera	3	1	808.306 N 628.036 E
Inversiones Samar	Samir Yasiggi	4	1	808.400 N 628.100 E

[26] It does not appear in “CVG-Minerven” register

APPENDIX 2 – Results of Hg in urine (LUMEX)

Code	Age	creatinine (g/L)	Hg µg/g creatinine		Group
NM-1A	11	0.47	0.10	<DL	CHILDREN
NM-2A	12	0.09	0.10	<DL	CHILDREN
NM-2B	13	0.09	72.57		CHILDREN
NM-10A	9	0.06	52.80		CHILDREN
NM-11A	10	0.38	16.53		CHILDREN
NM-13A	7	0.03	320.51		CHILDREN
NM-19A	9	0.66	27.43		CHILDREN
NM-21A	7	(*)	4.00		CHILDREN
NM-22A	7	0.19	0.10	<DL	CHILDREN
NM-23A	12	0.25	26.80		CHILDREN
NM-24A	10	1.25	129.60		CHILDREN
NM-24B	11	0.06	0.10	<DL	CHILDREN
NM-24C	14	(*)	45.00	(*)	CHILDREN
NM-25A	10	0.53	197.67		CHILDREN
NM-28A	10	0.03	86.54		CHILDREN
NM-29A	10	0.25	11.20		CHILDREN
NM-30A	8	0.09	29.88		CHILDREN
MT-12A	11	0.34	4.66		CHILDREN
MT-13A	12	0.41	24.37		CHILDREN
MT-15A	8	0.47	13.44		CHILDREN
MT-19A	12	0.66	19.81		CHILDREN
MT-23A	11	0.56	19.56		CHILDREN
MT-24A	13	0.63	17.60		CHILDREN
MT-25A	12	1.09	1.28		CHILDREN
MT-25B	8	0.31	0.10	<DL	CHILDREN
MT-29A	8	0.16	35.21		CHILDREN
MT-31A	9	0.16	0.10	<DL	CHILDREN
MT-32A	6	0.22	0.10	<DL	CHILDREN
MT-35A	7	0.47	0.10	<DL	CHILDREN
MT-36A	12	0.84	22.52		CHILDREN
MT-38B	12	1.09	134.41		CHILDREN
MT-38C	13	0.50	384.00		CHILDREN
MT-40A	13	0.72	10.85		CHILDREN
MT-40B	10	1.13	0.10	<DL	CHILDREN
MT-41A	10	1.09	4.94		CHILDREN
MT-45A	13	0.59	4.38		CHILDREN
MT-48A	7	0.38	9.87		CHILDREN
MT-50A	10	0.59	11.79		CHILDREN
MT-55A	10	0.06	22.40		CHILDREN
MT-57A	11	0.56	1.60		CHILDREN
MT-58A	6	0.56	0.10	<DL	CHILDREN
LF-7A	15	1.88	12.27		CHILDREN
LF-9A	12	0.09	149.41		CHILDREN
LF-11A	5	1.13	2.22		CHILDREN
LF-13A	11	1.56	18.56		CHILDREN

LF-13B	14	1.06	9.41		CHILDREN
LF-18A	11	0.16	15.36		CHILDREN
LF-18B	8	0.31	31.68		CHILDREN
CH-1A	15	0.88	0.10	<DL	CHILDREN
CH-1B	6	0.81	0.10	<DL	CHILDREN
CH-3A	13	0.72	0.10	<DL	CHILDREN
CH-5A	7	1.16	8.65		CHILDREN
CH-6A	7	1.13	4.00		CHILDREN
CH-8A	12	0.66	0.10	<DL	CHILDREN
CH-9A	10	1.03	0.10	<DL	CHILDREN
CH-14A	7	0.69	1.45		CHILDREN
CH-17A	7	0.44	13.26		CHILDREN
CH-20A	14	0.41	0.10	<DL	CHILDREN
CH-23A	8	(*)	0.10	<DL	CHILDREN
CH-33A	9	1.47	0.10	<DL	CHILDREN
LI-1B	13	0.94	0.10	<DL	CHILDREN
LI-2A	15	0.91	0.10	<DL	CHILDREN
MOC-01	20	0.94	106.67		MILLER
MOC-02	25	1.25	104.00		MILLER
MOC-03	33	2.50	52.40		MILLER
MOC-04	50	2.13	92.71		MILLER
MOC-05	42	1.00	140.00		MILLER
MOC-06	22	2.66	78.68		MILLER
MOC-07	24	1.06	24.47		MILLER
MOC-09	22	2.13	143.83		MILLER
MOC-11	42	1.38	420.36		MILLER
MOC-12	35	1.00	2030.00		MILLER
MOC-13	48	0.63	35.20		MILLER
MOC-14	32	2.50	192.00		MILLER
MOC-15	40	1.41	195.56		MILLER
MOC-16	38	1.06	10.35		MILLER
MOC-19	30	0.63	518.40		MILLER
MO-04	26	1.03	229.83		MILLER
MO-10	25	0.34	2781.50		MILLER
MO-14	36	1.06	43.29		MILLER
MO-17	40	1.56	1222.40		MILLER
MO-18	31	0.38	146.67		MILLER
MO-20	25	0.72	153.05		MILLER
MO-23	23	0.44	8.46		MILLER
MO-28	30	0.19	106.67		MILLER
MO-31	28	1.19	266.95		MILLER
MO-40	20	0.25	232.00		MILLER
MO-53	53	0.75	318.67		MILLER
MO-64	32	1.19	56.42		MILLER
MO-70	43	1.88	1221.33		MILLER
MO-78	22	2.34	1198.96		MILLER
MO-240	37	0.50	3260.00		MILLER
MO-243	22	0.97	84.65		MILLER
MO-245	32	1.47	130.05		MILLER
MO-247	25	0.28	149.36		MILLER

MO-249	52	0.63	41.60		MILLER
MO-260	36	0.78	1868.92		MILLER
MO-400	34	0.69	466.91		MILLER
MO-403	38	0.94	74.67		MILLER
MOLR-1	41	0.53	18.83		MILLER
MOLR-2	49	1.28	9.37		MILLER
MOLR-3	25	0.84	0.10	<DL	MILLER
MOLR-4	42	1.03	0.10	<DL	MILLER
MOLR-5	18	1.25	2.16		MILLER
MOLR-6	22	1.22	0.57		MILLER
MOLR-9	38	0.88	5.26		MILLER
MOLR-10	18	1.88	24.53		MILLER
MOLR-11	59	0.97	0.10	<DL	MILLER
MOLR-12	36	0.19	80.00		MILLER
MOLR-13	34	0.34	29.10		MILLER
MI-2	24	1.03	3.10		MINER
MI-3	48	0.94	12.80		MINER
MI-4	43	0.69	40.73		MINER
MI-6	20	1.25	2.64		MINER
MI-7	18	0.75	22.67		MINER
MI-10	29	0.03	0.10	<DL	MINER
MI-13	25	1.53	0.10	<DL	MINER
MI-17	29	3.13	14.72		MINER
MI-19	25	2.50	13.60		MINER
MI-21	26	1.88	0.10	<DL	MINER
MI-28	29	1.03	5.82		MINER
MI-32	22	1.00	1.60		MINER
MI-36	34	1.09	10.06		MINER
MI-46	41	2.66	37.65		MINER
MI-49	47	0.38	32.00		MINER
MI-100	38	0.44	25.14		MINER
MI-201	39	0.63	0.10	<DL	MINER
MI-202	48	1.25	17.60		MINER
MI-204	21	0.47	25.60		MINER
MI-205	56	0.34	23.86		MINER
MI-208	42	0.78	6.91		MINER
MI-209	49	2.13	10.35		MINER
MI-210	33	1.56	16.64		MINER
MI-211	22	0.91	2.10		MINER
MI-213	44	1.38	1.82		MINER
MI-216	39	2.19	3.84		MINER
MI-217	43	0.31	3.84		MINER
MI_218	21	1.34	2.38		MINER
MI-227	48	0.53	16.38		MINER
MI-304	39	1.84	54.78		MINER
MI-306	32	0.72	41.74		MINER
MI-308		0.31	30.08		MINER
MI-203	32	1.88	5.33		MINER
MT-09	26	1.41	167.12		WOMAN
MT-12	36	0.63	0.10	<DL	WOMAN

MT-13	36	2.06	20.85		WOMAN
MT-15	34	1.94	4.39		WOMAN
MT-18	42	0.53	32.00		WOMAN
MT-19	29	1.75	2.91		WOMAN
MT-23	40	0.81	13.54		WOMAN
MT-24	38	0.94	13.87		WOMAN
MT-25	31	0.56	0.10	<DL	WOMAN
MT-26	25	0.84	2.84		WOMAN
MT-29	24	0.38	26.67		WOMAN
MT-32	22	0.31	4.16		WOMAN
MT-34	23	0.75	1.87		WOMAN
MT-35	26	0.25	0.10	<DL	WOMAN
MT-36	45	0.78	4.99		WOMAN
MT-38	44	0.59	26.95		WOMAN
MT-40	25	0.91	0.44		WOMAN
MT-41	45	0.47	25.60		WOMAN
MT-45	33	0.56	0.10	<DL	WOMAN
MT-48	35	0.59	0.10	<DL	WOMAN
MT-50	25	0.97	23.74		WOMAN
MT-52	36t	1.63	5.23		WOMAN
MT-55	46	1.16	2.59		WOMAN
MT-57	36	0.69	26.18		WOMAN
MT-58	36	0.75	2.40		WOMAN
NM-02	36	0.09	45.89		WOMAN
NM-03	28	0.16	21.77		WOMAN
NM-05	28	0.41	27.08		WOMAN
NM-08	27	0.09	0.10	<DL	WOMAN
NM-10	25	0.59	10.61		WOMAN
NM-13	29	0.53	0.10	<DL	WOMAN
NM-17	17	0.59	0.10	<DL	WOMAN
NM-19	43	0.69	2.04		WOMAN
NM-21	27	0.09	77.91		WOMAN
NM-22	34	0.44	0.23		WOMAN
NM-23	30	0.28	13.87		WOMAN
NM-24	37	0.13	0.10	<DL	WOMAN
NM-26	25	2.34	19.20		WOMAN
NM-28	32	0.56	16.53		WOMAN
NM-29	37	0.16	17.93		WOMAN
NM-30	29	0.00	3.70		WOMAN
LF-01	19	1.19	0.10	<DL	WOMAN
LF-07	41	0.34	0.10	<DL	WOMAN
LF-08	36	1.16	16.43		WOMAN
LF-09	32	0.69	0.10	<DL	WOMAN
LF-11	35	0.13	0.10	<DL	WOMAN
LF-13	35	0.59	6.23		WOMAN
LF-14	29	1.03	15.52		WOMAN
LF-18	28	0.72	0.97		WOMAN
LI-01	35	2.00	5.18		WOMAN
LI-02	37	0.75	1.73		WOMAN
CH-01	45	0.63	3.84		WOMAN

CH-03	32	0.66	18.29		WOMAN
CH-05	25	0.19	0.10	<DL	WOMAN
CH-06	32	1.09	6.40		WOMAN
CH-08	45	2.66	24.47		WOMAN
CH-09	37	2.00	2.90		WOMAN
CH-14	43	0.38	26.67		WOMAN
CH-15	47	0.69	0.10	<DL	WOMAN
CH-17	25	0.38	23.47		WOMAN
CH-20	38	1.38	8.00		WOMAN
CH-25	25	0.88	0.10	<DL	WOMAN
CH-30	51	(*)	10.00		WOMAN
CH-33	37	0.53	12.42		WOMAN
CH-34	26	1.75	10.29		WOMAN
CH-23	28	<LD	0.10	<DL	WOMAN
AVERAGE		0.87	**104.59**		
STDev		0.63	**378.41**		

Legend

MT	From Monkey Town
NM	From Nuevo México
LF	From La Fábrica
LI	From La Iguana
CH	From Chile
DL	DETECTION LIMIT
(*)	no sufficient urine volume to analyze creatinine; result was considered 1 g/L

APPENDIX 3 – Analytical Method for Creatinine

Principle: Creatinine reacts with picric acid to form a yellow-reddish chemical complex; in acidic pH this reaction occurs with maximum production of the dyed complex creatinine-picrate.

In 3 test tubes – one for the blank, one for the standard and one for the urine sample - 2,0mL of the alkaline reagent is added. Then 0,25mL of distilled water is added to the blank test tube, 0,25mL of the creatinine standard, 3mg/dL to the standard tube and 0,25mL of centrifuged and diluted urine to the sample tube.

A 0,5mL of picric acid 60 mmol/L is prepared, homogenized and incubated in double boiler, at 37ºC, for 10 minutes.

The analysis is conducted in a spectrophotometer. The absorbances of the standard and sample are measured at 510nm (500 a 540), considering the blank test tube as zero.

The data is expressed in mg/dL are converted into g/L

APPENDIX 4 – Colorimetric Method to Analyze Total Hg

Dithizone is largely used as a colorimetric and extracting reagent (Koch and, Koch 1974 apud Silva, 1996)[27]. Dithizoate of mercury – Hg (HDz) – is formed in acidic medium with a red orange coloration. It is soluble in chloroform and carbon tetrachloride. This complex has absorbance at 485 nm and molar extinction of 71×10^4.

Through pyrolisis of soil or sediment, mercury is released and transferred to an acidic solution of potassium permanganate. After the total reduction of the solution with chlorohydrate of hydroxylamine, mercury is extracted with dithizone solution in chloroform. The color can be compared with standards previously prepared.

In order to extract Hg from the solid sample (soil or sediment), the test tube must be filled with 10g of the material, and about 1 mL of deionized water added. Sometimes the addition of some glass beads (15-20 beads) spreads the heat and facilitates the passage of Hg vapor through the soil/sediment layer. The test tube is heated with a Bunsen burner for 5 minutes. After waiting 3 minutes, the pyrolisis is repeated for another 5 minutes. The test tube is connected to a 250mL Becker, with 95 mL of sulfuric acid solution and 5 mL of potassium permanganate using a glass connector (tube). The solution is reduced with chlorohydrate of hydroxylamine.

An aliquot of 5 mL of the working solution is extracted, put in contact with ditizone in a decantation funnel and agitated for 1 minute. The ditizone solution is transferred to another decantation funnel with 50mL of alkaline solution. The funnel is agitated for 1 minute and the solution transferred to another decantation funnel containing acid washing solution. The funnel is agitated for another minute.

The final solution is transferred to a test tube and compared with standards previously prepared with concentrations of 0,2, 0,5, 1,0, 2,0 and 3,0 ppm Hg. When visually compared, it is advisable to use standard freshly prepared as Hg dithizone (HDz) is sensitive to light; these standards can be prepared with water and solutions of cobalt chloride and potassium dichromate.

[27] Silva, A.P., 1996. Mercúrio em Ambientes Aquáticos de Poconé-MT. Doctorate Thesis, University of São Paulo. Institute of Geoscience. São Paulo, Brazil. (in Portuguese).

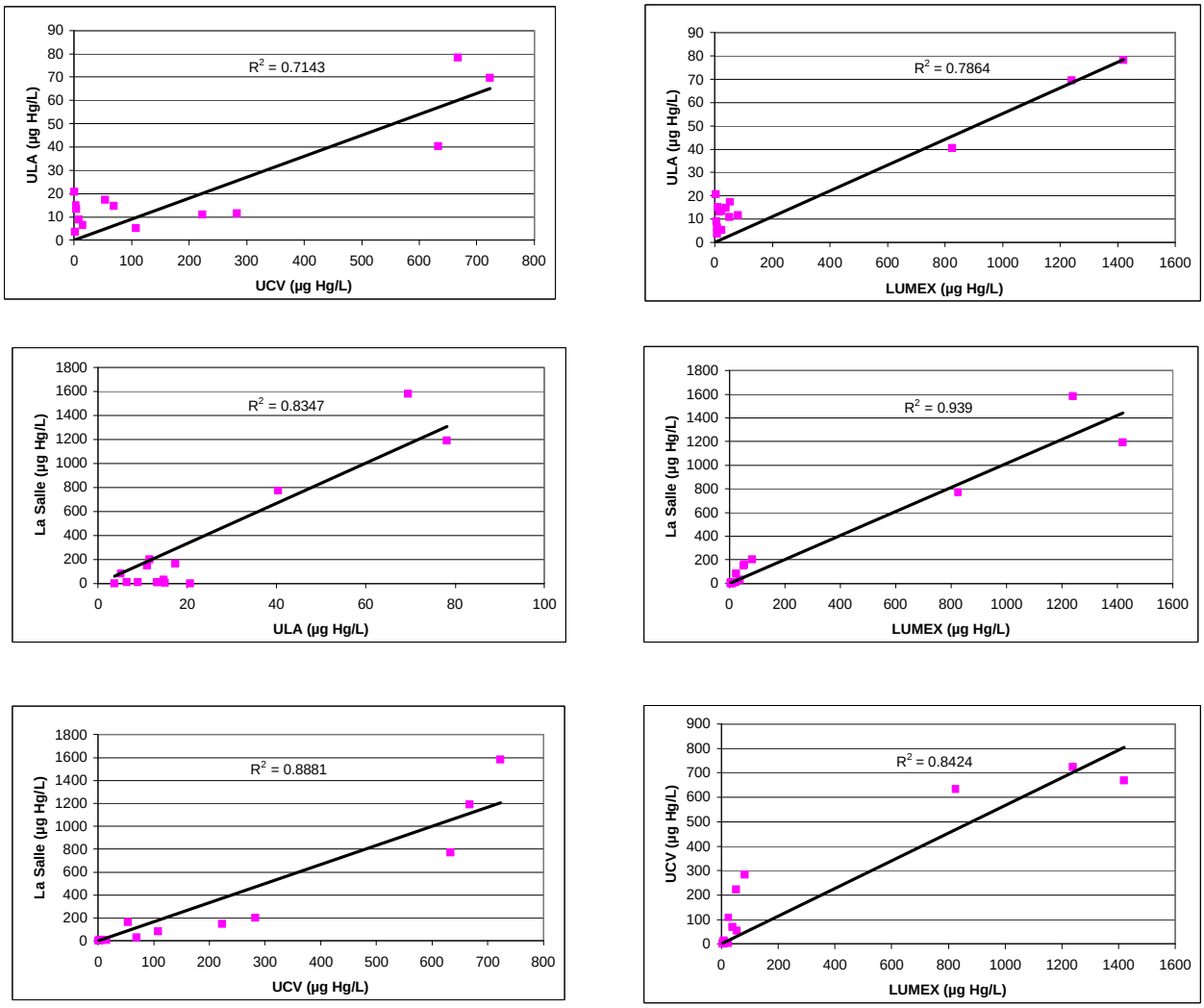
APPENDIX 5 – Interlaboratorial of Total Hg in Urine

Hg (µg/L) in Urine of Volunteers Analyzed by 3 Venezuelan Labs + LUMEX

	Hg (µg/L) UCV	Hg (µg/L) ULA	Hg (µg/L) La Salle	Hg (µg/L) LUMEX
CH-3	1	20.64	<4,00	4.7
CH-30	4.2	13.39	10	24
CH-8	15.2	6.43	9	7.7
LF-1	1.8	3.68	<4,00	9.15
MO-14	283	11.51	200	82.5
MO-260	633	40.35	770	826
MO-28	223	10.93	147	51.6
MO-31	54	17.3	162	54
MO-4	108	5.13	82	25
MO-70	668	78.17	1190	1420
MON-1	723	69.48	1580	1240
MT-50	69	14.69	29	39
NM-2	8.2	8.9	8	6.2
NM-30	3.3	14.99	4	11
MI-26	n.a.	13.25	10	17

Coefficients of Linear Correlation (R):

	UCV	**ULA**	**La Salle**	**LUMEX**
UCV		0.8452	0.9424	0.9178
ULA			0.9136	0.8868
La Salle				0.9690
LUMEX				



Correlation between Results from the Interlaboratorial Study

Note: R^2 = Coefficient of determination that represents the percentage of the data that is closest to the line of best fit

APPENDIX 6 – Censo Socioeconómico
Aplicado a las Comunidades del Bloque B, El Callao, Estado Bolivar, Venezuela
HECLA MINE - Gerencia de Relaciones con las Comunidades

by Gilberto Berrío

Marzo del 2004

OBJETIVO

El objetivo del presente informe en el marco del censo Socioeconómico aplicado por la empresa Minera Hecla Venezolana, CA, es diagnosticar las características de las comunidades ubicadas dentro del Bloque B sobre las condiciones de vida de las personas, perfil de las familias, condiciones laborales de las personas y vivienda que allí residen a fin

METODOLOGÍA

El presente informe se fundamenta en la aplicación de 393 encuestas en las cinco (5) comunidades ubicadas dentro de la concesión del Bloque B.

Comunidad	Total Familias
CHILE	90
LA FABRICA	76
LA IGUANA	49
MONKEY TOWN	97
NVO. MEXICO	81
Total general	**393**

Fuente: Censo Hecla, 2003

La aplicación del Censo SOCIOECONÓMICO se realizó de la siguiente manera:

- La comunidad de Perú-Chile y La Iguana en Diciembre del 2002
- La comunidad de Monkeytown en Enero del 2003
- La comunidad de La Fábrica-Buenos Aires y Nuevo México en Junio del 2003

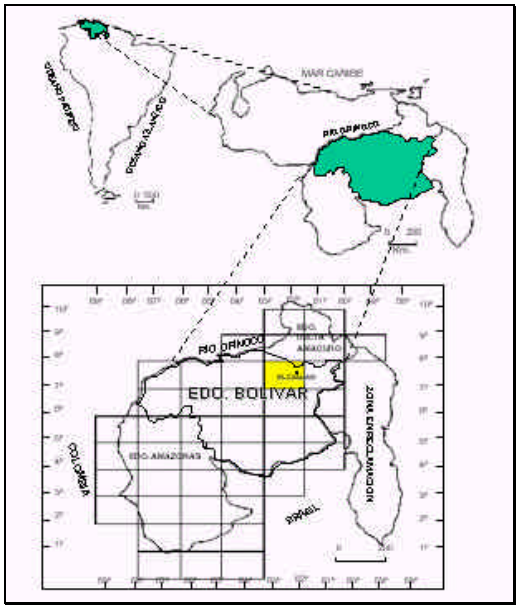
Hubo una participación institucional de entes como:

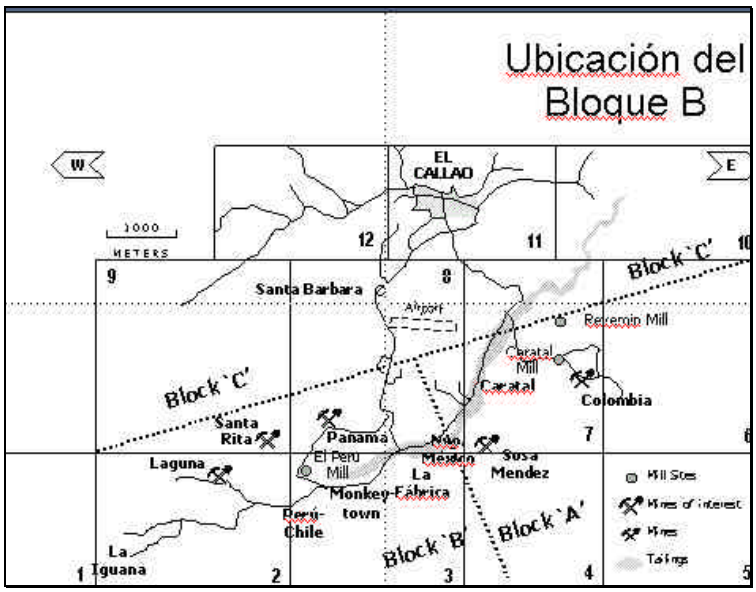
- La Guardia Nacional
- Alcaldía de El Callao

UBICACIÓN GEOGRÁFICA

El Bloque B se encuentra ubicado en Distrito Minero de El Callao, al sur de la localidad de El Callao en el estado Bolívar, Venezuela. El sistema de Coordenadas en uso es el Provisional Sur Americano, 1956. Las coordenadas aproximadas del centro de la propiedad son 626.600E y 807.800N, UTM.

El area total a ser afectada es de aproximadamente 80.000 m^2





INDICADORES ABORDADOS

De los indicadores abordados por el censo socioeconómico aplicado por minera Hecla Venezolana se analizarán para este informe para la ONUDI los siguientes:

- Características de la Familia
- Características de la Vivienda
- Condición Laboral

CONDICIONES SOCIOECONÓMICAS DE LAS COMUNIDADES

Referencia Estadística al Censo 2001

Según la población referida por el Censo aplicado por Minera Hecla Venezolana es de 393 familias que totalizan 1.731 habitantes. Esta población representa el 10% de la población del municipio El Callao, según el Censo aplicado por el gobierno venezolano en el año 2.001.

DISTRIBUCIÓN DE FAMILIAS ENTREVISTADAS Y HABITANTES POR COMUNIDAD
BLOQUE B, EL CALLAO, SEPTIEMBRE 2003

	Comunidad					
	CHILE	MONKEYTOWN	LA IGUANA	LA FABRICA	NVO MEXICO	**Total**
FAMILIAS ENTREVISTADAS	90	76	49	97	81	**393**
HABITANTES	411	433	147	359	381	**1,731**
HABITANTES DEL MUNICIPIO EL CALLAO (*)						**17,410**
HABITANTES DEL ESTADO BOLIVAR (*)						**1,214,486**

(*) Fuente Censo 2001
Fuente: Censo Hecla, 2003

De las comunidades del Bloque B, la Fábrica y Perú-Chile son las que tienen una representación de la mayor cantidad de familias (97 y 90 familias) mientras que La Iguana con la menor (49 familias).

Características de los Miembros de la Familia

De la información suministrada por los entrevistados sobre su grupo familiar, en lo referente a la predominancia del sexo, la relación porcentual de hombres es superior a la de las mujeres (53%) en el Bloque B, sobretodo en la comunidad de La Iguana (67%) y Perú-Chile (55%).

DISTRIBUCIÓN DE HABITANTES POR COMUNIDAD SEGÚN SEXO
BLOQUE B, EL CALLAO, SEPTIEMBRE 2003

SEXO	**CHILE**	**LA FABRICA**	**LA IGUANA**	**MONKEYTOWN**	**NVO MEXICO**	*Total*
FEMENINO	45.5	52.9	33.3	47.1	47.5	**46.9**
MASCULINO	54.5	47.1	66.7	52.9	52.5	**53.1**
Total	**411**	**359**	**147**	**433**	**381**	**1731**

Fuente: Censo Hecla, 2003

En lo referente a la distribución de los habitantes por grupos de edad, resalta la alta relación porcentual de los habitantes en menores a 18 años superior a las 2/5 partes de la población llegando a ser la mitad de la población en la comunidad de Perú-Chile. Sin embargo, en La Iguana, la 2/5 partes de la población son mayores a 56 años de edad.

DISTRIBUCIÓN DE HABITANTES POR COMUNIDAD SEGÚN GRUPOS DE EDAD
BLOQUE B, EL CALLAO, SEPTIEMBRE 2003

GRUPOS DE EDAD	CHILE	MONKEYTOWN	LA IGUANA	LA FABRICA	NVO. MEXICO	**TOTAL**
Menor de 18 años	50.12	43.65	23.13	44.29	47.24	**44.37**
De 19 a 55 años	44.77	51.04	37.41	48.75	44.62	**46.50**
56 años y más	4.38	4.62	21.77	4.74	4.20	**5.95**
Sin Información	0.73	0.69	17.69	2.23	3.94	**3.18**
Total	**411**	**433**	**147**	**359**	**381**	**1731**

Fuente: Censo Hecla, 2003

En cuanto al promedio de personas por vivienda es de 4 personas excepto La Iguana con 3 en promedio.

PROMEDIO DE HIJOS POR FAMILIA Y PERSONAS POR VIVIENDA Y COMUNIDAD
BLOQUE B, EL CALLAO, SEPTIEMBRE 2003

	CHILE	LA FABRICA	LA IGUANA	MONKEYTOWN	NVO MEXICO	**TOTAL**
PROMEDIO DE HIJOS POR FAMILIA	2.4	2.4	1.3	2.2	2.6	2.3
JEFE CON PAREJA	46.6	72.4	42.9	67.4	71.6	61.8
PROMEDIO DE PERSONAS POR VIVIENDA	3.7	3.7	2.5	3.6	3.7	3.5

Fuente: Censo Hecla, 2003

El promedio de hijos por familia es de 2 excepto Nuevo México que tiene la mayor representación con 3 niños. La Iguana es la comunidad que tiene la menor representación con un niño.

También, resalta que 2/3 de los habitantes de las comunidades de La Fábrica, Nuevo México y en menor grado Monkeytown tienen pareja, mientras que en La Iguana y Perú-Chile solo las 2/5 partes.

Nivel de Instrucción

Tal vez una de las áreas más sensible es lo referente al nivel de instrucción de los habitantes. Resalta el hecho que 1/5 parte de la población del Bloque sea analfabeta, particularmente la comunidad de la Iguana en la cual 2/5 son analfabetas.

DISTRIBUCIÓN PORCENTUAL DE LOS HABITANTES POR COMUNIDAD SEGÚN ANALFABETISMO
BLOQUE B, EL CALLAO, SEPTIEMBRE 2003

	CHILE	**LA FABRICA**	**LA IGUANA**	**MONKEYTOWN**	**NVO MEXICO**	**TOTAL**
ANALFABETISMO	27.7	19.5	42.2	18.0	21.0	23.3
SIN FORMACION ALGUNA (Cursos Técnicos, etc.)	98.1	90.0	99.3	96.1	96.1	95.6

Fuente: Censo Hecla, 2003

También, resalta que más del 96% de la población del Bloque B no ha realizado ningún tipo de curso técnico o de oficio por lo que se infiere que no existe una certificación adecuada para postular a trabajos con grandes empresas o actualización en el oficio de la minería.

DISTRIBUCIÓN PORCENTUAL DE LOS HABITANTES POR COMUNIDAD SEGÚN NIVEL DE INSTRUCCIÓN
BLOQUE B, EL CALLAO, SEPTIEMBRE 2003

NIVEL DE INSTRUCCIÓN	**CHILE**	**LA FABRICA**	**LA IGUANA**	**MONKEYTOWN**	**NVO MEXICO**	**TOTAL**
NINGUNA	31.63	21.73	46.94	21.48	25.20	**25.07**
PRE-ESCOLAR	0.49	1.67	0.00	0.69	1.31	**0.64**
PRIMARIA	52.31	38.16	43.54	42.96	46.98	**45.00**
SECUNDARIA	14.11	34.82	6.80	32.33	25.20	**24.73**
UNIVERSITARIO	0.97	3.62	2.72	1.62	1.31	**1.85**
SIN INFORMACION	0.49	0.00	0.00	0.92	0.00	**0.35**
TOTAL	**411**	**359**	**147**	**433**	**381**	**1731**

Fuente: Censo Hecla, 2003

En consonancia a lo anterior, ¼ parte de los habitantes no tiene ningún tipo de nivel de instrucción, mientras que 2/5 partes sólo llega a primaria (6to grado) y ¼ a secundaria. Sólo el 2% de la población a nivel técnico o universitario.

Características De La Vivienda

Las características de la vivienda se definieron tomando en cuenta: Tipo de pared, tipo de techo y tipo de Piso.

DISTRIBUCIÓN PORCENTUAL DE VIVIENDAS POR COMUNIDAD SEGÚN TIPO DE PAREDES
BLOQUE B, EL CALLAO, SEPTIEMBRE 2003

TIPO DE PAREDES	CHILE	LA FABRICA	LA IGUANA	MONKEY TOWN	NVO.MEXICO	TOTAL
BLOQUE	22.2	64.5	18.4	70.1	66.7	**50.9**
ZINC	40.0	2.6	51.0	10.3	1.2	**18.8**
MADERA	27.8	7.9	2.0	17.5	4.9	**13.5**
BAHAREQUE	7.8	17.1	16.3	1.0	21.0	**11.7**
HULE	2.2	0.0	0.0	0.0	0.0	**0.5**
SIN INFORMACION	0.0	7.9	12.2	1.0	6.2	**4.6**
TOTAL	**90**	**76**	**49**	**97**	**81**	**393**

Fuente: Censo Hecla, 2003

En lo referente a las paredes de las viviendas en el Bloque B, de cada 10, 5 son construidas con bloque, 2 con zinc, 1 en madera y 1 con barro. Resalta el hecho que en la comunidad de La Iguana de cada 4 viviendas, 2 son construidas con láminas de zinc, 1 con bloques o barro. Caso similar se repite en la comunidad de Perú-Chile de cada 10, 4 son construidas con láminas de zinc, 3 con madera, 2 con bloque y 1 con barro. Al contrario, en las comunidades de La Fábrica, Monkeytown y Nuevo México de cada 3 viviendas, 2 son construidas con bloque y 1 con barro.

DISTRIBUCIÓN PORCENTUAL DE VIVIENDAS POR COMUNIDAD SEGÚN TIPO DE TECHO
BLOQUE B, EL CALLAO, SEPTIEMBRE 2003

TIPO DE TECHO	CHILE	LA FABRICA	LA IGUANA	MONKEY TOWN	NVO.MEXICO	TOTAL
ZINC	98.9	75.0	87.8	97.9	79.0	**88.5**
PLATABANDA	0.0	3.9	0.0	0.0	11.1	**3.1**
ACEROLIT	0.0	7.9	0.0	1.0	2.5	**2.3**
TEJA	0.0	5.3	0.0	0.0	1.2	**1.3**
HULE	1.1	0.0	0.0	0.0	0.0	**0.3**
SIN INFORMACION	0.0	7.9	12.2	1.0	6.2	**4.6**
TOTAL	**90**	**76**	**49**	**97**	**81**	**393**

Fuente: Censo Hecla, 2003

En el Bloque B, de cada 10 vivienda 9 tienen techo de zinc. Resalta las comunidades de Perú-Chile y Monkeytown en las cuales casi la totalidad son de zinc.

DISTRIBUCIÓN PORCENTUAL DE VIVIENDAS POR COMUNIDAD SEGÚN TIPO DE PISO
BLOQUE B, EL CALLAO, SEPTIEMBRE 2003

TIPO DE PISO	CHILE	LA FABRICA	LA IGUANA	MONKEY TOWN	NVO.MEXICO	TOTAL
CEMENTO	56.7	81.6	32.7	91.8	92.6	**74.4**
TIERRA	43.3	6.6	55.1	6.2	1.2	**19.8**
BALDOSAS	0.0	2.6	0.0	0.0	0.0	**0.5**
MADERA	0.0	1.3	0.0	1.0	0.0	**0.5**
CEMENTO	0.0	0.0	0.0	0.0	1.2	**0.3**
SIN INFORMACION	0.0	7.9	12.2	1.0	6.2	**4.6**
TOTAL	**90**	**76**	**49**	**97**	**81**	**393**

Fuente: Censo Hecla, 2003

Con respecto al tipo de piso, de cada 4 viviendas del Bloque B, 3 tienen el piso de cemento y 1 de tierra. Resalta el hecho que en la comunidad de la Iguana de cada 3 viviendas, 2 lo tienen de tierra y 1 de cemento, mientras que en la comunidad de Perú-Chile de cada 2 viviendas 1 lo tiene de cemento y una de tierra.

Servicio Público

De los servicios públicos abordados fueron: Tipo de alumbrado, tipo de sumnistro de agua y tipo de excusado.

DISTRIBUCIÓN PORCENTUAL DE VIVIENDAS POR COMUNIDAD SEGÚN TIPO DE FUENTE DE LUZ

BLOQUE B, EL CALLAO, SEPTIEMBRE 2003

FUENTE DE LUZ	CHILE	LA FABRICA	LA IGUANA	MONKEY TOWN	NVO.MEXICO	**TOTAL**
ELECTRICIDAD	95.6	92.1	44.9	99.0	93.8	**89.1**
NO TIENE	4.4	0.0	40.8	0.0	0.0	**6.1**
PLANTA	0.0	0.0	2.0	0.0	0.0	**0.3**
SIN INFORMACION	0.0	7.9	12.2	1.0	6.2	**4.6**
TOTAL	**90**	**76**	**49**	**97**	**81**	**393**

Fuente: Censo Hecla, 2003

La fuente de luz de las viviendas ubicadas en el Bloque B provienen principalmente de la electricidad (89%), a excepción de la comunidad de La Iguana que tan sólo 2/5 partes tienen acceso a ella.

DISTRIBUCIÓN PORCENTUAL DE VIVIENDAS POR COMUNIDAD SEGÚN TIPO DE SUMINISTRO DE AGUA

BLOQUE B, EL CALLAO, SEPTIEMBRE 2003

TIPO DE SUMINISTRO DE AGUA	CHILE	LA FABRICA	LA IGUANA	MONKEYTOWN	NVO.MEXICO	**TOTAL**
CISTERNA	100.0	21.1	65.3	86.6	23.5	**56.2**
TUBERÍA	0.0	71.1	0.0	12.4	70.4	**31.3**
RÍO	0.0	0.0	22.4	0.0	0.0	**2.8**
SIN INFORMACION	0.0	7.9	12.2	1.0	6.2	**4.6**
TOTAL	**90**	**76**	**49**	**97**	**81**	**393**

Fuente: Censo Hecla, 2003

En cuanto al suministro de agua a las habitantes del Bloque B, se realiza principalmente con camiones cisternas (56%) que llevan el agua a las comunidades. Tan sólo un 1/3 tiene suministro de agua por tubería. Es importante destacar, que las comunidades de la Fábrica y Nuevo México las 2/3 partes tienen acceso de agua por tubería aunque no es permanente. La comunidad de Perú – Chile sólo se surte de agua por camiones cisterna, mientras que la comunidad de la Iguana 2/5 partes ni siquiera cuentan con suministro de agua por camiones cisternas, sino que tienen que recurrir a una quebrada con agua salobre.

Tal vez este es uno de los problemas más sensible de estas comunidades

DISTRIBUCIÓN PORCENTUAL DE VIVIENDAS POR COMUNIDAD SEGÚN TIPO DE SERVICIO DE EXCUSADO

BLOQUE B, EL CALLAO, SEPTIEMBRE 2003

TIPO DE SERVICIO DE EXCUSADO	CHILE	LA FABRICA	LA IGUANA	MONKEY TOWN	NVO.MEXICO	**TOTAL**
LETRINA	54.4	81.6	28.6	92.8	72.8	**69.7**
EL MONTE	44.4	1.3	57.1	6.2	2.5	**19.6**
NINGUNO	1.1	9.2	2.0	0.0	18.5	**6.1**
SIN INFORMACION	0.0	7.9	12.2	1.0	6.2	**4.6**
TOTAL	**90**	**76**	**49**	**97**	**81**	**393**

Fuente: Censo Hecla, 2003

Al igual que el servicio de agua, el servicio de excusado es álgido. No existe en toda el área ningún tipo de cloaca. De cada 3 viviendas, tan sólo 2 tienen letrina. El caso es más sensible en la comunidad de la iguana que la relación es de cada 3 viviendas tan sólo 1 tiene letrina.

En la comunidad de Perú-Chile de cada 2 viviendas 1 solamente tiene letrina. Esto se empeora por la ubicación topográfica de las viviendas que se encuentran en la parte baja de un valle, de manera que cuando llueve los desechos orgánicos bajan.

Condición Laboral

La condición laboral se abordó mediante dos variables: Por una parte, Ocupación definida la actividad que se encuentran realizando al momento de la entrevista. Por la otra parte, Oficio entendida como la percepción de la persona sobre la actividad que está preparado para realizar.

DISTRIBUCIÓN PORCENTUAL DE LOS HABITANTES POR COMUNIDAD SEGÚN OCUPACIÓN

BLOQUE B, EL CALLAO, SEPTIEMBRE 2003

OCUPACION	CHILE	LA FABRICA	LA IGUANA	MONKEYTOWN	NVO.MEXICO	TOTAL
ESTUDIANTE	26.0	34.5	10.2	30.7	34.6	**29.5**
DESEMPLEADO	27.0	17.0	29.3	17.3	19.9	**21.1**
DEL HOGAR	18.5	20.6	18.4	20.1	18.6	**19.4**
MINERO	19.2	12.8	4.8	21.0	11.5	**15.4**
OBRERO	3.9	3.1	6.1	1.8	1.8	**2.9**
COMERCIANTE	1.2	1.9	0.7	3.0	5.2	**2.7**
AGRICULTOR	0.5	0.6	24.5	0.5	0.5	**2.5**
Otro	3.6	9.5	6.1	5.5	7.6	**6.4**
TOTAL	**411**	**359**	**147**	**433**	**381**	**1731**

Fuente: Censo Hecla, 2003

Es interesante observar que el 30% de la población del Bloque B define su ocupación como estudiante, 21% como desempleado, 19% oficios del hogar y el 15% como minero. Es interesante observar que tanto las comunidades de Monkeytown como Chile define su ocupación minero en un 20%. A diferencia de las otras comunidades, en la comunidad de La iguana el 25% de la población se percibe como agricultor.

DISTRIBUCIÓN PORCENTUAL DE LOS HABITANTES POR COMUNIDAD SEGÚN OFICIO

BLOQUE B, EL CALLAO, SEPTIEMBRE 2003

OFICIO	CHILE	LA FABRICA	LA IGUANA	MONKEYTOWN	NVO.MEXICO	TOTAL
NINGUNA	81.8	85.0	89.1	87.3	92.9	**86.9**
ESTUDIANTE	7.5	2.8	0.0	1.8	0.0	**2.8**
MINERO	1.9	0.6	0.0	1.6	0.0	**1.0**
SECRETARIA	0.0	2.8	0.7	0.7	0.8	**1.0**
MECANICO	1.5	0.8	0.7	0.5	1.0	**0.9**
ALBAÑIL	1.9	0.6	1.4	0.7	0.0	**0.9**
COMERCIANTE	1.2	0.3	0.0	1.6	0.5	**0.9**
Otro	4.1	7.2	8.2	5.8	4.7	**5.7**
TOTAL	**411**	**359**	**147**	**433**	**381**	**1731**

Fuente: Censo Hecla, 2003

En lo referente al oficio definido por las personas para el cual están preparado para trabajar casi la totalidad manifiesta que no tiene ninguna. Ni los mismas personas que desarrollan la actividad minera manifiestas que estén preparado para realizarlo, no se sienten identificado con la actividad.

Cuadro Resumen

CARACTERÍSTICAS DEL GRUPO FAMILIAR Y SUS MIEMBROS	CHILE	LA FABRICA	LA IGUANA	MONKEYTOWN	NVO MEXICO
INDICE DE MASCULINIDAD	119.8	89.0	200.3	112.3	110.5
GRUPOS DE EDAD PREDOMINANTE	Menor de 18 años (50%)	Entre 19 y 55 años (51%)	Mayor de 56 años (40%)	Entre 19 y 55 años (49%)	Menor de 18 años (47%)
PROMEDIO DE HIJOS POR FAMILIA	2.4	2.4	1.3	2.2	2.6
JEFE CON PAREJA	46.6	72.4	42.9	67.4	71.6
PROMEDIO DE PERSONAS POR VIVIENDA	3.7	3.7	2.5	3.6	3.7
ANALFABETISMO	27.7	19.5	42.2	18.0	21.0
SIN FORMACION ALGUNA (Cursos Técnicos, etc.)	98.1	90.0	99.3	96.1	96.1
NIVEL DE INSTRUCCIÓN PREDOMINANTE	83% Hasta Primaria	73% Primaria-Secundaria	90% Hasta Primaria	75% Primaria-Secundaria	72% Primaria-Secundaria
OCUPACIÓN PREDOMINANTE	Desempleado - Minero	Desempleado - Minero	Desempleado - Agricultor	Minero - Desempleado	Desempleado - Minero
OFICIO	Ningún	Ningún	Ningún	Ningún	Ningún

CARACTERÍSTICAS DE LA VIVIENDA	CHILE	LA FABRICA	LA IGUANA	MONKEY TOWN	NVO.MEXICO
TIPO DE PAREDES	Zinc - madera	Bloque - Barro	Zinc -Bloque	Bloque - Madera	Bloque - Barro
TIPO DE TECHO	Zinc	Zinc	Zinc	Zinc	Zinc
TIPO DE PISO	Cemento - tierra	Cemento	Tierra - cemento	Cemento	Cemento
FUENTE DE LUZ	Electricidad	Electricidad	No tiene electricidad	Electricidad	Electricidad
TIPO DE SUMINISTRO DE AGUA	Cisterna	Tubería - cisterna	Quebrada - cisterna	Cisterna	Tubería - Cisterna
TIPO DE SERVICIO DE EXCUSADO	Monte - letrina	Letrina	Monte	Letrina	Letrina

APPENDIX 7 - Photos

Copper amalgamation plates

Hammer mill and copper plates

First box built to support Goldtech plates

Second (zigzag) box built to support Goldtech plates

El Mago Processing Center: Goldtech plates reducing Hg emissions

Cleangold boxes being used

Carpets (introduced by UNIDO) replacing Cu-plate to concentrate gold

Miner burning amalgam

Retort locally made using kitchen stainless steel bowl

Home-made retort made of water pipes

Thermex retort being used

Other type of retort locally manufactured

"Venezuelan Retort"

"Venezuelan Retort" in operation

Banner at the Processing Center

Kid in the Processing Centers

Demonstration day

Demonstrating the use of retorts

Applying health questionnaire to miller

Applying health questionnaire to miller

Analyzing Hg in exhaled air with LUMEX

Miller blowing into the LUMEX

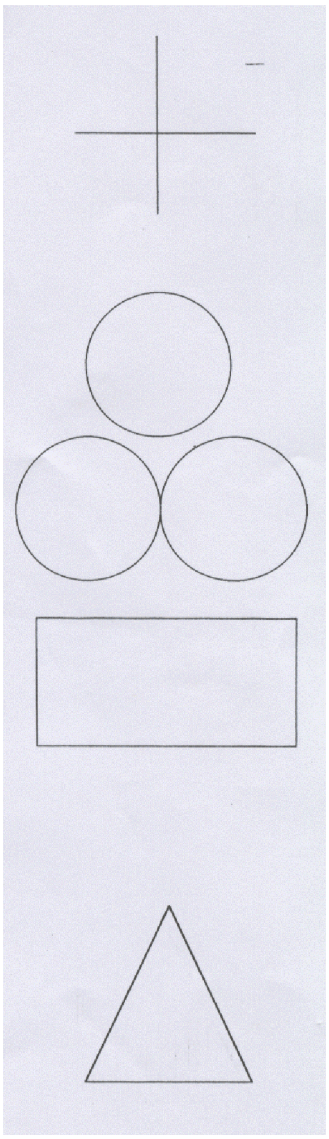
Mr. S. Penna (UDO) and Mr L. Pedroso (CETEM) analyzing urine

Introducing urine sample into LUMEX

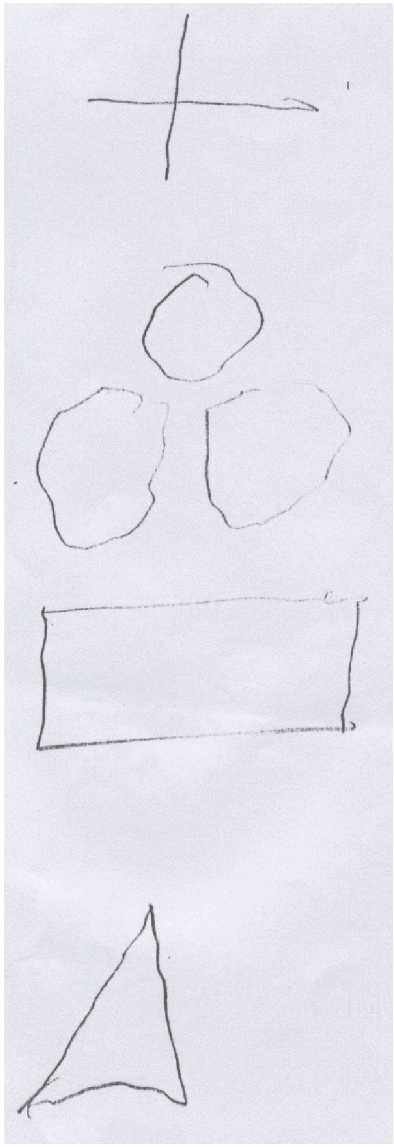
Copying Figures

(Drawings of a miller, 36 years-old, with long history of burning amalgam in shovels)

Figure to be copied



His drawing



UNIDO project team in the workshop in El Callao

Definitely, there are better places to play than a Processing Center: it is just a matter of opportunity and help