WWF Guianas

Mercury Contamination, A Legacy to Handicap a Generation

By

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Introduction

National agencies and international organizations are investing considerable resources to facilitate the improvement of the livelihood and living conditions/quality of life of the peoples of the Guianas. These efforts include improvements of health care, education, training and physical infrastructure. However, a silent enemy in the form of mercury contamination may be cutting the very legs out from under these efforts. A major problem facing the Guianas with various degrees of attention is the release of mercury from alluvial gold-mining activities to the environment. Mercury poisoning of local peoples is an unostentatious problem that may have profound ramifications for future generations.

Gold mining in Guianas

Small to medium-scale and artisanal goldmining has become an important part of the Guianas, socio-economic landscape particularly for the communities (Maroons and Amerindians) of the interior and the Brazilian garimpeiros. The total production estimates are quite high, ranging from 10,000 kilograms to more than 20,000 kilograms annually for Suriname[21,27], this production is predominantly from very small operations of 1 to 10 miners. This represents a body of people estimated to be between 15,000 and 20,000 involved in gold mining in Suriname. For Guyana, official estimates indicate that small-scale miners recover more than 3,500 kilograms of gold per year[20,26,], while large-scale mining is a greater effort with official estimate indicating 8,500 kilograms per year. The a workforce of goldmining sector in Guyana is approximately 11,000 persons.. The French Department of La Guyane (French Guiana) officially produces more than 3,000 kilograms[25] of gold every year with unofficial production estimated at 6,000 to 9,000 kilograms per year. Mining is conducted by small- and medium-scale operations but also by artisanal miners. The department estimates about 100 official gold-mining sites employing about 1,000 workers, however, the number of clandestine gold diggers is estimated to be between 10,000 and 15,000, spread over several hundreds sites[13]. Thus, in the three Guianas as much as 40,000 kilograms of gold are being extracted per year. The most common small to medium scale goldmining method is hydraulicking. Hydraulic monitors, sometimes working in conjunction with excavators, spray water under pressure to disintegrate and mobilize alluvial and colluvial material that contains the gold particles. The slurry is pumped to sluice boxes, where gravity concentration takes place to separate the heavy minerals including the gold particles from the lighter waste minerals. The concentrate containing gold is collected for further processing, usually through mercury amalgamation. Tailings are discarded locally. Most of these operations are located near or in stream courses, resulting in great potential for contamination of water by siltation, heavy metals and mercury[22].

Figure 1: Medium scale gold mining in the Guianas

The use of mercury in gold mining and how it is released to the environment

There are multiple possible sources of mercury input to the environment in the Guianas, including the mercury released from soils and vegetation during slash and burn clearing of rain forest and aerial transport and deposition from external areas However, the total mass released from placer gold mining activities overshadows these other inputs. Mercury is employed by gold miners in three general modes[23]: 1) The mercury is placed on the floor or riffles of the sluice box to contact the bulk ore, 2) the mercury is spread on bulk ore on the ground prior to running through the sluice box, and 3) mercury is used to amalgamate the gravity concentrate from the sluice box. The use of mercury in sluice boxes and on bulk ore results in release of large amounts of the toxic metal to the environment; fortunately, these practices do not seem to be universally applied in the Guianas. Loss of mercury to the environment through these first two methods can result in three or more times as much mercury being released to the environment as mass of recovered gold[19]. For amalgamation of gravity concentrates, concentrates are placed in a pan or some other receiver and are mixed with mercury. Miners typically add two parts of mercury to amalgamate one part of gold. Excess mercury is squeezed off through a piece of fabric (this is done by hand) **Figure 2**; miners usually recover about half of the mercury for reuse during the physical separation process. The gold/mercury amalgam is then heated to volatilize the mercury; thereby releasing a 1:1 ratio of mercury to the environment for each mass of produced gold. Much of this mercury is deposited locally as wet or dry precipitation.

Figure 2: Amalgam being processed by hand.

Retorts can be used to recover the volatilized mercury for reuse[22], but these are not consistently used in the Guianas because of cost, extra time required, lack of experience, noise, absence of regulations and other reported reasons. Even with the use of retorts, gold from the mines may contains up to 5% or more mercury. This gold dore is transported to the capital cities for sale and further refining, resulting in release of mercury in the urban environment. No accurate data are available for the amount of mercury used in gold-mining operations or for the actual amount of mercury released to the environment. At minimum, the mass of mercury lost from gold-mining operations and thus available to pollute the environment in the Guianas is equal to—but likely much greater than—the amount of gold that is produced. Estimates for the amount of mercury released into the French Guiana environment from 1854 to 1950 range from 200,000 to 300,000 kilograms. Current estimates for French Guiana are that 5,000 to 10,000 kilograms of mercury are being dumped every year by gold-mining activities. For comparative purposes, at the scale of the Amazon region, the annual discharge of mercury from gold mining into the ecosystem is estimated to reach about 300,000 kilograms[4]. For the three Guianas, with gold production estimates ranging upwards of 40,000 kilograms annually[25,26,27], equating to a minimum of 40,000 kilograms of mercury released, the scale of contamination of the Guiana's ecosystems complex, including air, soil, sediment, water, animals, foodstuffs, and humans, is daunting. The significance of mercury pollution can be illustrated by the fact that the concentration levels of these media is measurable and has significant effects in the part per million (microgram of mercury per gram of media --10^{-6} g/g) and part per billion (nanogram of mercury per gram of media --10^{-9} g/g) range. USEPA has established that ingesting 1.1 µg methylmercury/kg body weight/day over a long period of time can cause adverse effects in humans[8] . A child with a body burden of less than 0.002 grams of mercury can experience debilitating effects.

Scientific data on mercury contamination in the Guianas environment

More data are needed to characterize the distribution and degree of contamination. Nevertheless, studies conducted to date in the Guianas provide strong evidence of environmental mercury contamination. Elevated mercury levels have been documented in every environmental compartment searched by scientific investigators—soil, sediment, wildlife, and people. Data indicate a strong relation between the occurrence of mercury and gold mining. Gold-processing activities are a predominant source of mercury contamination—an unsurprising, fairly common-sense conclusion given the large mass of mercury used in the industry.

Mercury bioaccumulates in the food web, thus, fishes are a good indicator of the presence of mercury in the environment. Mol et al[15]., 2001, observed that mercury concentrations in fish species were significantly higher in areas impacted by goldmining (average of 0.71 µg/g for higher trophic level, predatory species) than in non-gold-mining background areas (average of 0.25 µg/g for predatory species). Additional significant findings in their study were that 57% of higher trophic-level predatory fish exhibited mercury levels in excess of the Maximum Permissible Concentration level of 0.5 µg/g assigned by WHO[24].

De Kom et al[12]., 1998, tested and compared results for people involved in mining with people not involved in mining and documented that urine mercury levels (indicative of recent exposure to metallic or vapor mercury forms) were significantly higher for the mining population (average of 27.5 µg/g creatinine) as compared with the non-mining population (average of 5.2 µg/g). Interestingly, blood mercury analyses—indicative of longer-term exposure to mercury from sources including methylmercury in diet—indicated both mining and non-mining populations had been exposed to mercury.

With WWF-Guianas funding, Quik and Ouboter[17], 2000, (Center of Environmental Research, University of Suriname) found that mercury levels in predatory fish in the Commewijne River, Suriname averaged about 0.5 µg/g, just at the safety threshold for consumption of fish. 33% of the predatory fish exceeded the WHO maximum permissible concentration. The scientists also found that mercury levels in both sediment and fish were higher in the Upper to Middle Commewijne reaches as compared with the lower Commewijne, indicating a possible identification of gold-mining activities--which are common in the upper reaches of the river--as a source of mercury contamination.

Figure 3Testing of mercury levels in fresh water creeks.

With WWF– Guianas funding, David Singh et al[18]., 2000, (Guyana Institute of Applied science and Technology) conducted studies in the Kurupung and Isseneru areas of Guyana to identify the occurrence and assess the levels of mercury contamination in humans, and in the environment. The results showed that during two sampling events--February and September 2000--12% and 14% of the

population, respectively, in the Kurupung area had concentrations greater than 14 µg/g (WHO minimum known adverse effect limit on adults used in Singh's analysis). The results from Isseneru were appalling: 96% and 89% of the population had concentrations greater than the limit for sampling events—February and September. These findings corroborate the fact that Isseneru is dominated by gold-mining activities while Kurupung is predominantly a diamondiferous area where gold is not extensively mined and mercury is not required for processing.

The Guyana Geology and Mines Commission[10], 2001, performed an aquatic study in the Potaro River and found that 57% of the carnivorous fishes had elevated mercury levels above the maximum WHO level (0.5 µg/g) ; none of non-carnivorous fishes sampled had that level of contamination.

In Suriname, Gray et al[11]., 2002, found that mercury levels in mine-waste sediment and mine waters in Suriname were highly elevated in comparison to local baseline concentrations. Total mercury concentrations for mine waters ranged up to 0.93 µg/l; methylmercury concentrations in mine waters ranged up to 0.0038 µg/l. Water mercury levels generally exceeded the 0.012 µg/l EPA[8] standard for protection against chronic adverse effects to aquatic life. Total mercury concentrations for mine-area sediments ranged up to 0.20 µg/l; methylmercury concentrations in mine area sediments ranged up to 0.0014 µg/l.

A study carried out in 1997 in Wayana amerindian villages[1] of the upper Maroni river in French Guiana showed that 57% of the people had a mercury concentration in their hair above 10 µg/g (the average being 12µg/g). These high concentrations were linked to the fish consumption. A 15 to 45 years old Wayana eats about 350 grams of fish per day. The levels of fish contamination are so high that the quantity of mercury ingested per week (between 200 and 450 µg/g) was equal or even twice the tolerable weekly level as accepted by WHO, and even up to 10 times higher than the new references levels of USEPA.

Another study carried out in 1999, Frery et al.[9] in Wayana Amerindian villages showed that 99,6 % of the Wayana population had mercury concentrations in the hair above 4,4µg/g, which is twice the concentration of a population that is not exposed to mercury.

Figure 5: Hair sampling

Perhaps the most worrisome study findings in Suriname to date are from Mohan et al[14]., 2003. This group of obstetrician/gynecologists measured mercury levels in the hair and urine of mothers and newborn babies from a cross-section of ethnic groups and locations (urban and interior). In comparison with background hair mercury concentration levels set forth in the Journal of the American Medical Association (1999) which stated a 1.4 µg/g background for mothers and 0.4 µg/g for babies, the researchers found that 36% of the mothers and 95% of the babies exhibited elevated hair mercury concentrations. Mean maternal hair concentration was 1.8 µg/g, ranging up to 15.4 µg/g; mean infant hair concentration was 2.6 µg/g, ranging up to 19.6 µg/g. Urine mercury concentrations were not found to be elevated, this finding strongly implicates the presence of methylmercury, which is typical in persons diet including contaminated fish, as the source of contamination. These data are of concern in that evidence from a number of medical studies shows that developing fetuses are sensitive to mercury, and children of mothers exposed to mercury may show signs of toxic effects where mothers have as little as 6 µg/g hair mercury concentrations. The number of replicates may not be enough for statistically or scientifically valid conclusions, however, these results are worrisome.

The effect of mercury on people

Mercury is moderately to extremely toxic to humans. The degree of risk varies depending on several factors including: 1) the quantity of mercury to which a person is exposed, 2) the form of mercury, 3) the frequency of exposure, 4) the person's stage of life, and 5) individual sensitivity to mercury. Mercury can impinge upon the body in several forms. In order of increasing toxicity the common forms are: metallic mercury (liquid "quicksilver"), ionic mercury (usually dissolved in water), mercury vapor (present in air), and methylmercury (an organic mercury form usually ingested in food, especially fish). The potency of methylmercury in producing irreversible brain damage and birth defects makes it of greatest public concern.

High-level exposure to mercury vapor, and to a lesser extent metallic mercury, can result in nervous system damage causing tremors, as well as mood and personality alterations. Broad, systemic effects occur on kidneys, lungs, muscle, liver, cardiovascular, gastrointestinal system, and circulatory systems. Exposure to ionic mercury in inorganic mercury salts can cause kidney damage and nervous system damage. Exposure of adults to relatively high levels of methylmercury through fish consumption results in numbness or tingling in the extremities, sensory and coordination loss, nervous system damage, and a range of systemic effects similar to those for metallic and mercury vapor exposure.

Figure 6: Burning of amalgam for extraction of gold.

The cause of most metallic and vapor mercury poisoning is rather direct, and can be avoided with use of simple equipment and workplace safety procedures. Metallic and vapor mercury affect a rather small part of the population—people involved in gold recovery and processing.

Methylmercury concentrates and bioaccumulates in the food web and affects an important regional protein source, i.e. fish and wild animals dependent on fish. This organic form of mercury has the potential for imparting significant harm to a much broader swath of the population. Elemental mercury serves as the source of methylmercury which forms through biogeochemical reaction of

mercury with organic matter. Ingestion of fish which have bioaccumulated methylmercury is globally, the most common means of mercury poisoning. The most alarming effects of methylmercury poisoning occur in developing fetuses and children and it is known to cause teratogenic effects in children born to exposed mothers. Exposure of an unborn child through maternal diet can cause neurologic developmental abnormalities in cognitive and motor functions. The manifestations in infants of even relatively low-level exposure of the mother to methylmercury prior to birth include: 1) delayed developmental milestones such as walking and talking, 2) altered muscle tone and tendon reflexes, and 3) depressed intelligence or mild retardation. Higher-level exposure can cause more drastic effects such as severe central nervous system problems, severe retardation, and stunted limb development.

There are relatively few studies on the affects of methylmercury on developing children or fetuses, and there is still debate on what threshold levels of impact are. USEPA[10] has documented that mothers who had hair concentrations as low as 6 μg/g during pregnancy had children who exhibited decreased mental and physical development and function. The USEPA has established a Reference Dose (RfD) of 0.1 μg/kg body wt./day to protect brain development in young children; this RfD is expected to achieve a no adverse effect level in children. For pregnant women, EPA uses a dose-conversion equation to estimate that a daily intake of 1.1 μg methymercury/kg body wt./day ingested by a 60 kg person will maintain a maternal hair concentration of 11 μg Hg/g. This benchmark dose was estimated to produce a 10% prevalence of adverse effects in children (at a 95% confidence level). The degree of exposure and individual sensitivity can determine whether symptoms of mercury poisoning are expressed. The effects of environmental contamination, consequent food contamination, and resulting mercury poisoning on the young are potentially insidious, generally irreversible, and rob individual potential.

Awareness of mercury contamination effects on the environment and people

Most miners and people with a potential for the more direct mercury exposure pathways through exposure to metallic mercury or mercury vapor[16] are not aware of the toxicity and dangers of mercury from diet and the affect on children. The degrees of separation between mercury source, environmental sinks, bioaccumulation, and ultimate human intake are great enough that cause and effect are far from obvious. This presents a challenge that must be met in order to protect the population—to educate, bring awareness and to incite action to ameliorate the problem. The issue of mercury and general public understanding is fraught with complex, vague, and often dangerously erroneous concepts. An intelligent approach, understandable by non-technical people with varying levels of education, is necessary to move miners towards the adoption of improved practical methods. . Governmental agencies charged with protecting health and environment in the Guianas currently do not recognize or at least do not assign adequate importance to the threat of mercury in diet. Medical doctors in Suriname are noting an increased incidence of mild to severe birth defects—central nervous system problems, stunted limb development, etc—that may be ascribed to mercury poisoning (Mohan et al., 2003 above). There are no medical facilities in the Guianas for testing and diagnosis human mercury intoxication. In French Guiana, neurological examinations and psychological tests carried out in 1997 with the Wayana people evidenced deficiencies--especially for children--who exhibited decreased coordination of legs and decreased visual-spatial organization capacity. These effects were linked with the ingestion of mercury.

Figure 7: Aerial view from degraded land due to gold mining

The State Forest Service in French Guiana (Office National des Forêts) ONF has developed in partnership with DRIRE (Direction Régionale de l'Industrie, de la Recherche et de l'Environnement) and DIREN (Direction Régionale de l'Environnement) awareness material (leaflets) on the reduction mercury emissions in the environment, use retorts, and other best practice methodologies.

The Guyana Environmental Capacity Development Mining Project (GENCAPD), which aimed at strengthening the environmental management capacities of key mining sector institutions in Guyana, has developed and distributed in the different goldmining districts a series of mercury related awareness materials to support their program of testing, demonstration and distribution of retorts.

WWF-Guianas in collaboration with the management authorities in the Guianas is currently developing a program to increase the awareness of environmental and health issues pertaining to the goldmining sector. An article " A Chemical Time Bomb" which depicts the impacts of mercury pollution in the Guianas was published and widely distributed in the Guianas, Latin America and the Caribbean.

In Brazil, a pilot awareness program was started in a village on the Tapajos river, in the area of Santarem[4,6]. Meetings were held with the villagers and posters were distributed in order to invite people to 'eat more fishes that do not feed on other fishes'. Five years after this awareness campaign, the level of mercury measured in the hair of these people had significantly decreased.

Figure 8: Retort heated on fire with kuoy to recover mercury.

Actions needed

The common denominator in the complex socio-environmental problem of managing mercury contamination and minimizing human exposure is the control of the use and release of metallic mercury. Making local governmental planners, policy makers, and the general population aware of environmental mercury contamination and the ultimate effect on people—particularly from encroachment of mercury on diet—is a first step in addressing the problem. This must be followed by efforts for reducing intake of contaminated fish, particularly by pregnant women and young children.

Important steps are the promotion and adoption of viable, locally applicable alternative mining approaches to minimize environmental and health mpact[22,23]. The reduction and eventually elimination of mercury to the environment can be achieved through the adoption of unambiguous goldmining policy, strengthening of governmental institutions charged with environmental, monitoring, introduction and adoption of low-mercury or mercury-free gold-processing methodologies; e.g. shaking tables Figure 9, centrifuges, and other gravity concentration methods, chlorination processes, use of retorts, centralized processing centers, etc. Greatest efficiency can be obtained if people interacting directly with gold miners are aware of the toxic effects of mercury, methods to minimize emission and are capable of recognizing critical situations. The rehabilitation of goldmining sites through replanting and reestablishing site geomorphologic and hydrologic conditions to a more natural state is an important step in the battle to reduce the release of mercury in the environment. As mercury use begins to be controlled and eventually banned and release to the environment is reduced, monitoring efforts should continue in order to provide an ongoing assessment of the status of the environment, food supply, and public health, and to evaluate the efficacy of efforts to improve conditions.

Figure 9: Gemini shaking table

In French Guiana, some small- to medium-scale companies have already started to work without mercury, using shaking tables and centrifuges. By Prefectoral Decree of June 2004, the use of mercury for gold extraction will be prohibited in French Guiana starting January 1, 2006 However, if similar measures are not taken in Suriname and Guyana and more stringent monitoring in Brazil this decree might be ineffective because of the porous borders and the fact that the goldmining is often carried out beyond the reach of state control and monitoring. In Brazil, mercury use is illegal, however, controls and enforcement are weak, thus, mercury is still widely used[19].

Conclusion

Goldmining activities are becoming increasingly important in the socio - economic landscape of the Guianas, but are leaving an insidious legacy of mercury poisoning crippling a broad swath of a new generation and reducing the potentials of those individuals upon whose shoulders the future of the region rests. Mercury poisoning could not only cause failure of current efforts to improve socioeconomic conditions, but could further burden a weak economy, social services and health-care system with children growing to adults with mental and physical handicaps and a general population with reduced productivity and ability to support social services.

Mercury contamination is also affecting other countries in South America, but the Guianas lag behind considerably in defining, recognizing, and moving to address the problem. Many of the tools and methodologies developed or adopted in the other countries to reduce and eventually stop goldmining related mercury release have great applicability/potential to the Guianas.

The solution rests upon the adoption of unambiguous goldmining policy, the implementation of well targeted awareness program, the promotion of improved goldmining and adoption of mercury free techniques and the establishment of good monitoring program, and the empowerment of strong enforcement institutions.

Figure 10: Environmental degradation due to poor mining practices.

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