

**Final report for the project**

**SuriMerc**

**Strengthening Surinamese involvement in activities  
related to mercury pollution in Suriname**

**submitted to the**

**United Nations Environment Programme (UNEP)**

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## **Summary**

The project “SuriMerc” (Strengthening Surinamese involvement in activities related to mercury pollution in Suriname) was funded by the United Nations Environment Programme (UNEP) within the framework of “SUPPORTING COUNTRY EFFORTS TO TAKE ACTION ON MERCURY POLLUTION”. The duration of the project was 14 months. Activities initiated during the project will be continued beyond the duration of the project. This report summarizes the achievements of project. Additional information is available on the project website, available under <http://www.iup.physik.uni-bremen.de/mercury/> .

The overall aim of the project “SuriMerc” was to build the necessary capacity in Suriname to take action on mercury pollution. The Anton de Kom University of Suriname (AdeKUS) was the focus of the capacity building activities. All the proposed activities have been successfully completed. For the measurement location a modification to the proposal was necessary. Beyond the proposed activities the project facilitated the writing of two proposals. The first proposal for a Lumex RA 915 mercury analyzer was successful. This analyzer ensures that instrumentation for mercury research will be available at the AdeKUS in the future, which is important for the sustainability of the mercury activities at the AdeKUS. The second proposal has been submitted to UNIDO and has the aim to include Suriname in the Global Mercury Project.

## **Background**

Mercury has a variety of documented, significant adverse impacts on human health and the environment (UNEP, 2002). In the Amazon region large amounts of mercury are released in the environment as a result of small-scale and artisanal gold mining. It is estimated that in Suriname 20000 kg/year are discharged into the environment by small-scale and artisanal gold mining (Mol et al., 2001). These amounts are one order of magnitude larger than other important mercury sources in Suriname, namely bauxite refining industry and biomass burning. The emissions from biomass burning are estimated to be about 30 kg/year (Mol et al., 2001) and the emission by bauxite refining were estimated to be 500- 600 kg/year in 2002-2003 and below 150 kg/year in 2005 from “Suriname Aluminum Co.” (SURALCO), the largest company in Suriname (Suralco, 2003).

The artisanal and small scale gold mining<sup>1</sup> activities in Suriname are described in detail in a UNIDO-report (Veiga, 1997). The mining activities are taking place in the greenstone belt in the southeast of Suriname, where miners are dispersed in an area of approximately 20,000 km<sup>2</sup>. The government is not present in this difficult accessible area and therefore there is almost no Government control on the mining operations. Artisanal gold mining in this region is still increasing, due to a lack of opportunities for unskilled people in the interior and due to migration of Brazilian gold miners to Suriname. The Brazilians are coming to Suriname because of a shortage of easily extractable gold in Brazil and easy access for Brazilians to Suriname. Efficient gold-extraction methods are not known to most of the miners resulting in high amounts of used mercury. In many cases the whole ore is amalgamated, which could result in mercury losses of 3 times the amount of gold produced. The lack of knowledge about the danger of mercury vapors and a diet heavily relying on river fish results in high exposure of the miners and their families.

The threats of mercury exposure are not limited to the interior. The gold miners sell the gold to jewelry shops in the City of Paramaribo. During the purchasing process, the gold is melted and the residual mercury, which usually accounts for about 3 to 5 % of the weight is released. The gold dealers in Paramaribo that are registered by the Central Bank and enforced to use condensers for mercury abatement during the gold melting operation. In addition to the registered gold dealers there are many Chinese jewelers in Paramaribo that often pay a better price for the gold. The Chinese jewelers usually do not use any safety protection or filter to melt the gold. This results in mercury emissions that potentially represent a serious health hazard to the population of Paramaribo. For Paramaribo mercury levels in air that highly exceed the limit for public exposure are reported for the on the webpage of the Suriname Indigenous Health Fund (<http://www.sihfund.org>). Since the credibility of these measurements is not ensured high quality atmospheric mercury measurements are needed for Paramaribo, which will be part of this proposal.

Quantitative data assessing the mercury contamination in Suriname is rare. The limited existing data suggest that the contamination is alarming. Total Hg and methyl-Hg concentrations measured in mine wastes, stream sediments and surface waters in the Brownsveg area indicate that the contamination is similar to the one found near artisanal gold

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<sup>1</sup> Artisanal and small scale mining (ASM) is used to denote all small-scale as well as medium and large-scale mining activities characterized by a lack of long-term mine planning and the use of rudimentary techniques, be they illegal or legal, formal or informal.

mines in Brazil where Hg contamination has led to adverse effects to tropical ecosystems and that artisanal gold mining throughout Suriname poses potential health threats to humans and aquatic wildlife (Weaver, 2004). The accumulation of mercury in humans has two main pathways in the Amazon (Veiga, 1997): (1) miners and goldshop workers are exposed to vapors of metallic mercury and (2) nonoccupational groups are primarily exposed to methyl mercury in fish. In Suriname, small-scale miners had elevated mercury levels of 27.5 µg/g creatinine in their urine (De Kom *et al.*, 1998). In some Amerindian villages along the Marowijne River up to 79% of the children had abnormal high hair mercury levels 10 µg/g due to the consumption of freshwater fish (Cordier *et al.*, 1998). Mercury levels in hair from mothers delivering in a hospital in Paramaribo showed elevated Hg concentrations in about one third of the mothers and 80% of the newborns had a higher mercury level in hair than their mothers (Mohan, et al., 2005).

In the appendix of the Global Mercury Assessment report (UNEP, 2002) it was stated that “Limited information was provided with regards to legislation or ongoing activities to reduce release of mercury in Suriname.” The reason is that in Suriname activities to reduce the mercury pollution are not well established (e.g. in comparison to Brazil) and lack coordination. Within this project we will conduct a “Training for Trainers” workshop to learn from the experience by others (especially the Global Mercury Project) in training of gold miners and employ these techniques to a selected group of gold miners. Furthermore we set up an advisory panel that advises ongoing activities and identifies targets for future activities to reduce mercury pollution.

## **1. Capacity building at the Anton de Kom University of Suriname**

The Anton de Kom University of Suriname is the only University in Suriname. Despite the high environmental mercury pollution in Suriname, the Anton de Kom University of Suriname was not strongly involved in research related to mercury pollution in the environment. The reasons are that the Anton de Kom University lacked a) knowledge about environmental mercury research and b) instrumentation to perform quantitative mercury analysis in environmental samples. One main goal of this proposal was capacity building at the Anton de Kom University of Suriname and to actively involve the Anton de Kom University of Suriname in mercury research. Within this project atmospheric mercury measurements have been performed. A Tekran mercury analyzer for the atmospheric measurements and technical assistance have been provided by the University of Bremen to Dennis Wip, a lecturer from the Anton de Kom University. Dennis Wip is now successfully running the Tekran mercury analyzer in Suriname. Dennis Wip has started with PhD-research on mercury pollution in Suriname under the supervision of Prof Justus Notholt from the University of Bremen. The aims are that after completion of the PhD Dennis Wip will be a) integrated in the international mercury research community b) pursues with mercury research in Suriname and c) promotes mercury research and outreach activities at the Anton de Kom University in Suriname. The promotion of mercury research at the the Anton de Kom University will produce skilled people available for mercury activities within Suriname. Furthermore this will provide a basis to attract third-party funds for mercury research to Suriname (e.g. participation in EU-projects). In course of the project Mr Wip took part in the research school “Persistent pollution: past, present and future” organized by the Institute of Coastal Research from the GKSS Research Centre. Initiators of the school were Ralf Ebinghaus and Markus Quante. The group of Ralf Elbinghaus is strongly involved in mercury measurements and modeling and is an important partner related to our mercury measurements in Suriname. Mr Wip is doing the modeling of the atmospheric transport of mercury in close cooperation with the GKSS. He also visited the Institute for Environmental Physics at the University of Bremen to discuss his PhD studies with Prof. Justus Notholt and Dr. Thorsten Warneke. He also had the opportunity to get in close contact with other PhD-students at the University of Bremen and of attending a PhD defence. The proposed activities 1.1, 1.2, 1.3 and 1.4 have been successfully completed as proposed (Table 1).

**Table 1** Status of the proposed activities related to capacity building

Activity	Status
Activity 1.1: The University of Bremen will provide a mercury analyzer to perform quantitative mercury analysis in ambient air in Suriname for the duration of 18 months.	Successfully completed
Activity 1.2: The University of Bremen will provide technical training to staff of the Anton de Kom University of Suriname in atmospheric mercury measurements.	Successfully completed
Activity 1.3: The University of Bremen will supervise and guide PhD-research, performed by a lecturer at the Anton de Kom University.	Successfully completed
Activity 1.4: The library at the Anton de Kom University will be upgraded with relevant literature.	Successfully completed

## 2. Quantifying atmospheric mercury concentrations

The proposed activities 2.1, 2.2, 2.4, 2.5 and 2.6 have been successfully completed as proposed (Table 2). The measurements at the study area (Activity 2.5) will be continued beyond this project.

During the first months we have focused on measurements in the City of Paramaribo. After the measurements in Paramaribo we have moved the Tekran to a location at the coast, where it is still measuring. This is a modification to our initial plans. It was proposed to identify a study area in the Greenstone Belt (Activity 2.3) and to perform measurements with the Tekran at this location. We have modified our plans for the location of the Tekran mercury analyzer for the following reasons:

- a) We have discussed our plans for the mercury measurements with modelers from the group of Daniel Jacobs (Harvard University) and the group of Ralf Ebinghaus (Institute of Coastal Research from the GKSS Research Centre). The outcome of this discussion was that tropical background measurements of atmospheric mercury in the tropics are urgently needed to constrain global transport of mercury. Currently the tropical background is not well known and models agree not with measurements (e.g. Selin et al. JGR 2007). High precision mercury measurements exist in the tropics only for a few campaigns, but no tropical measurements over a longer time period exist. Since the Tekran is an instrument which can measure mercury with high precision (0.2 ng/m<sup>3</sup>) we had the unique opportunity to use it for the measurement of tropical background concentrations of atmospheric mercury. We have performed a trajectory study and identified a coastal location in Suriname as a suitable location for the background measurements. After the measurements in Paramaribo we have moved the Tekran to a location at the coast, where it is still measuring.
- b) We have written a proposal for a Lumex mercury analyzer. The Lumex mercury analyzer has a precision of 2 ng/m<sup>3</sup>, which is ten times lower than the precision of the Tekran mercury analyzer. The advantage of the Lumex is that it is portable and can also be used for solid and liquid samples. For atmospheric measurements the Lumex is suited for the measurements in the Greenstone Belt but not for the measurement of tropical background concentrations. Therefore we will use the Lumex for the

measurements in the Greenstone Belt. We expected to be able to perform these measurements within the time span of this proposal. However, due to a delay between the acceptance of the proposal and the transfer of the money the Lumex mercury analyzer is expected to be delivered not earlier than February 2008.

- c) A suitable location that fulfills the requirements for both, the infrastructure for a sensible instrument like the Tekran and a suitable location to study the impact of the gold-mining activities was not found. The Lumex mercury analyzer is more robust and is therefore better suited for measurements in these measurements.

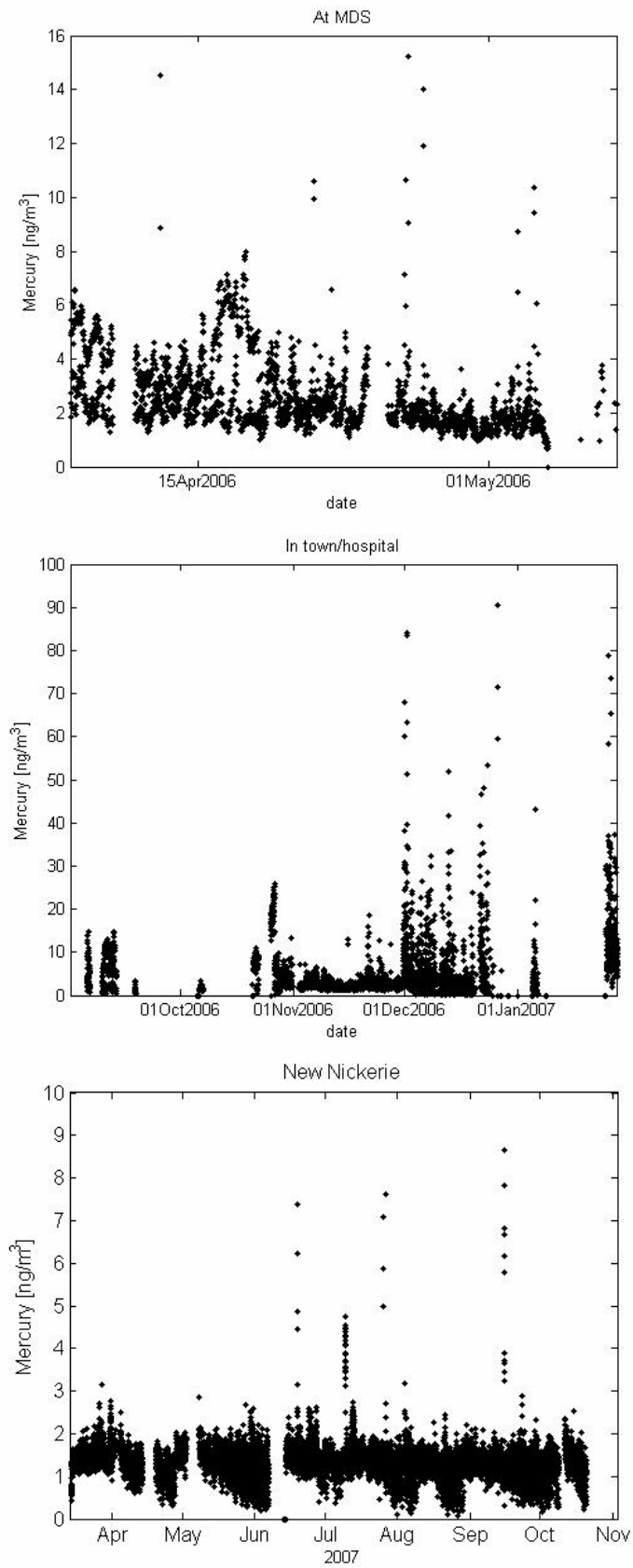
Measurements in Paramaribo were performed at an outer-city (Fig. 1a) and an inner-city (Fig. 1b) location. The concentrations in the City of Paramaribo are significantly higher than the tropical background concentrations of mercury (Fig 1c). The reasons are emissions from gold shops in the City of Paramaribo. During the purchasing process, the gold is melted and the residual mercury, which usually accounts for about 3 to 5 % of the weight is released. The gold dealers in Paramaribo that are registered by the Central Bank are enforced to use condensers for mercury abatement during the gold melting operation. In addition to the registered gold dealers there are gold shops in Paramaribo that often pay a better price for the gold, but do not use condensers. These shops and potential also the registered shops contribute to the higher values in Paramaribo. The mercury levels in air that we have measured in Paramaribo do not exceed the limit for public exposure. This is in contrast to measurements reported for the on the webpage of the Suriname Indigenous Health Fund. In the final report our measurements will be discussed in detail.

Measurements have also been performed in a large gold shop (OUROMINAS) in Paramaribo using the LUMEX Hg spectrometer. These measurements have been performed during a field trip as part of the “Training for Trainers” workshop (Activity 4.1) in February 2007. The OUROMINAS is one of the largest gold buyers of Paramaribo. The company is buying in its 3 shops around 2.5 tones/a of gold. Operators melt the gold in front of the miners and the difference in weight before and after the melting is mainly attributed to mercury that is evaporated. The shop has a fume hood with two very large water tanks to wash the gases being exhausted. The water tanks are too large and the fan loses charge thus not extracting efficiently mercury vapor from the shop. As a result the interior of the shop has levels ranging from 30,000 to 65,000 ng/m<sup>3</sup> due to low exhaustion and lack of ventilation in the shop.

Considering that the WHO guidelines suggest maximum level for worker's exposure working 8h/day  $25,000 \text{ ng/m}^3$ , the levels of mercury of this shop are very high. According to Dr. Veiga the water tanks are too large, so that they restrict the air flow and reduce the effectiveness of the fume hoods due to insufficient suction. The manager showed his concern and promised to change the exhaustion process increasing power of the fan and reducing the size of the ducts and water tanks.

**Table 2** Status of the proposed activities related to atmospheric measurements

Activity	Status
Activity 2.1: Establishment of a methodology for the atmospheric mercury measurements.	Successfully completed
Activity 2.2: Atmospheric mercury measurements at the Meteorological Service of Suriname in the southwestern outskirt of Paramaribo.	Successfully completed
Activity 2.3: Identification of a study area in the Greenstone Belt.	See comment
Activity 2.4: Transportation to and installation of the mercury analyzer at the study area.	Successfully completed
Activity 2.5: Atmospheric mercury measurements in the identified study area.	Ongoing measurements
Activity 2.6: Atmospheric mercury measurements at key locations in the City of Paramaribo	Successfully completed
Activity 2.7: Interpretation of the measurements with respect to the impact on ecosystems and human health.	Ongoing



**Figure 1:** Atmospheric mercury measurements in Suriname using the Tekran mercury analyzer a) at the Meteorological Service in the southwestern outskirts of Paramaribo, b) at the St. Vincentius Hospital in the City of Paramaribo c) background measurements at the coast close to New Nickerie

### 3. Supporting activities related to mercury pollution in Suriname

In Suriname activities to reduce the mercury pollution are not well established. Within the project “SuriMerc” people, who are involved in activities related to mercury pollution have been brought together as indicated in the proposal. This facilitated the writing of a proposal to include Suriname in the Global Mercury Project. This proposal has been submitted to UNIDO and the AdeKUS and the Ministry of Natural Resources are the coordinating agencies. A second proposal for a Lumex RA 915 mercury analyzer was already successful. This analyzer ensures that instrumentation for mercury research will be available at the AdeKUS in the future, which is important for the sustainability of the mercury activities at the AdeKUS.

**Table 3** Status of the proposed activities related to supporting activities

Activity	Status
Activity 3.1: Identification of possible stakeholders and establishment of an advisory panel.	Successfully completed
Activity 3.2: Three advisory panel meetings during the project.	Successfully completed
Activity 3.3: Identification of problems related to mercury pollution and proposal of solutions.	Successfully completed
Activity 3.4: Identification of targets for future activities.	Successfully completed

#### 4. Introduce safer and cleaner technologies for gold extraction to gold miners

In February 2007 a Training for Trainers workshop was held in Paramaribo. The workshop was conducted by Mr. Marcello Veiga (GMP-UNIDO) and Mrs Janis Shandro (UBC Dept. Mining Engineering, Canada). The course consisted of 3 days of lectures (24 hours) and 2 days in the field. The topics approached in the course were: environmental problems caused by mercury from artisanal gold miners around the world, health effects of elemental mercury and methylmercury, principles of gold processing, methods to improve recovery and reduce mercury use, methods to improve amalgamation and retorting, ways to diversify the economy of artisanal mining communities, the Global Mercury Project: its strategy and methodology, and methods to implement awareness campaigns.



Fig. 2: Opening of the SURIMERC Training for Trainers workshop by the Minister of Environment Mrs. Joryce Amarello – Williams, on 19th of February 2007

A field trip to the National Park of Brownsberg, as part of the workshop, revealed the presence of about 600 illegal artisanal gold miners working within the park boundaries using

hydraulic monitors with sluice boxes and burning mercury in open pans. One common practice in Suriname is to spread mercury on the carpets of the sluice box at the end of the concentration process. It was shown to miners that this manual amalgamation practice is inefficient and the amalgamation of the concentrates from the carpets in barrels is better. It was also shown that the use of “activated mercury” can trap fine gold. The demonstration used two 1.5V radio-batteries which are not very effective for fast activation of the mercury. However, using copper wires, it was possible to demonstrate the effectiveness of the process to clean the mercury and to amalgamate gold faster and with less loss of mercury. The destruction of the park became evident as several abandoned areas were identified. The mining of alluvial/colluvial material is not deep (max 5 meters) and the eroded coarse quartz particles are not processed. The gold recovery in the process is estimated between 20 and 30%. The natural rehabilitation of the degraded areas does not seem very rapid since all organic part of the soils was removed.

The participants of the workshop included

- Governmental participants (field inspectors and officers of the Ministries of Health, Environment and Labor, mine inspectors of the Ministry of Natural Resources, Participants of the Meteorological Department of the Ministry of Public Works);
- University participants (Economists, Chemists, Physicists and Mining Experts);
- Leading workers of Concessionaries;
- A WWF expert and two Consultants (anthropologists).

One of the concession holders demands now the use of retorts in the process of gold exploitation within his concession. The success of this top-down approach will be monitored. It is planned to establish regular contact with the participants of the workshop. Six months after the training all participants of the workshop were invited to share their experience with regard to passing on the acquired knowledge and information, by sending in a questionnaire.

The proposed course about mercury in the environment is offered to students for the first time at the AdeKUS this autumn. The title of the course is “Mercury pollution in the Environment”. It is an optional course at the department of Geology and Mining. It contains 30 hours theory and 15 hour practicals.

## Contents of the course:

### I.

- Why is it important to study mercury and mercury related issues?
- Mercury is a neurotoxin
- Mercury sources
- Mercury emissions
- The atmospheric mercury cycle
- Mercury deposition (dry and wet)
- Mercury accumulation in sediments

### II.

- Mercury and mercury pathways in the aquatic food chains
- Consequences of mercury pollution in the environment
- Accumulation of Mercury and biological halftime (Metabolic Model)

### III.

- Atmospheric measurements of mercury (possibly also measurements in sediments and water bodies)
- Clean gold extraction techniques
- Remediation of mine sites
- Retorts and their use

**Table 4** Status of the proposed activities related to training of miners

Activity	Status
Activity 4.1: A “Training for trainers” – Workshop in close cooperation with relevant institutions and organizations, among others Dr. Marcello Veiga, the Chief Technical Advisor of the GEF/UNDP/UNIDO will be carried out.	Successfully completed
Activity 4.2: Elements of cleaner technologies for small scale and artesinal gold mining will be implemented in the curriculum of the Anton de Kom University of Suriname.	Successfully completed
Activity 4.3: Exposed populations will be identified.	Successfully completed
Activity 4.4: Training of miners in a selected test area .	Ongoing

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