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**Preparation of a global legally binding instrument
on mercury**

Methodologies for determining mercury exposure in people involved in artisanal and small-scale gold mining

Note by the secretariat

1. At its first session, held from 7 to 11 June 2010, the intergovernmental negotiating committee to prepare a global legally binding instrument on mercury requested the secretariat to prepare information on methodologies for determining mercury exposure in people involved in artisanal and small-scale gold mining. The information requested is set out in the annex to the present note and has been prepared in consultation with the partnership area on artisanal and small-scale gold mining within the Global Mercury Partnership of the United Nations Environment Programme. It has been reproduced as received from the leads of the partnership area, and has not been formally edited.

2. The information includes introductory material on mercury; methods for determining levels of exposure, including fish sampling and medical examinations; a brief presentation of case studies; and conclusions.

3. The committee may wish to take note of this information, along with that provided in the document entitled “Guidance for identifying populations at risk from mercury exposure”. The executive summary of that document is available to the committee in the six languages of the United Nations under the symbol UNEP(DTIE)/Hg/INC.2/19, whereas the full text is available in English only under the symbol UNEP(DTIE)/Hg/INC.2/INF/3.

* UNEP(DTIE)/Hg/INC.2/1.

Annex

Methodologies for determining exposure in people involved in artisanal and small-scale gold mining

A. Introduction

1. Artisanal and small scale gold mining (ASGM) is a poverty-driven activity that provides an important source of livelihood for rural communities. As the price of gold has been increasing to record highs, the number of artisanal gold miners has risen to between 10 and 15 million people worldwide, producing from 500 to 800 tonnes of gold/a and emitting as much as 1200 tonnes/a of mercury.

2. Artisanal and small scale gold miners extract gold from the ore by mixing liquid metallic mercury with wet ore (the resulting mixture is called mud). The mercury binds to the gold (and also silver) creating an amalgam. The remaining mud and metallic mercury are often washed away, thus contaminating the surrounding environment. The gold or silver amalgam is then heated to vaporize the mercury releasing it into the atmosphere. Workers at these mining operations experience dermal contact with mercury and breathe the vapour. Accidental ingestion may also occur. Breathing mercury vapours from heated amalgam is the most critical of the three routes of exposure (dermal, inhalation, ingestion) since inhaled metallic (elemental) mercury is easily absorbed and distributed throughout the body. Elemental mercury will cross blood-brain and placental barriers and can cause neurophysical, neuropsychological, and cognitive effects. Miners are exposed directly, but others may also be exposed if amalgam is burned indoors without proper ventilation such as in homes and “gold shops”. Family members, other workers, and neighbours can be exposed in this way. Environmental mercury contamination also results in increased mercury levels in local fish. Consumption of contaminated fish is another pathway of mercury exposure for the communities around artisanal mining operations.

3. It is widely accepted that while the particular circumstances of ASGM are country-specific, there are common elements in problems associated with ASGM across country settings. As such, solutions to reduce the risks of mercury in these communities need a globally consistent and effectively coordinated approach in order to deal with these complex problems at local level.

4. As part of the Global Mercury Project (GMP) of UNIDO, a Health Assessment methodology was designed to complement the Environmental assessment, providing indicators of the level of Hg poisoning and its health effects on ASM and surrounding communities by exposure to Hg vapors, by ingestion of contaminated food, (in particular fish), or both.

5. The Health Assessment combines information from biological samples associated with medical exams to evaluate the level of exposure that the pollutant caused or may cause to individuals. This is a basic procedure to evaluate potential risks and prioritize mitigation actions. While the Health Assessment methodology presents general guidance for such assessments, the particular sampling procedures used must be site-specific, taking into consideration the consideration the characteristics of the mining activity; the biodiversity of the region; the accessibility and availability of resources; risks; logistics; etc.

6. One of the main points to be investigated in a Health Assessment is the pathway by which Hg bioaccumulates in humans. The main ways are through inhalation of metallic Hg vapor from amalgam burning (and gold melting) and ingestion of fish with high moderate methyl mercury (MeHg) concentrations. Mercury vapor released during amalgam decomposition poses a serious hazard to workers and surrounding communities. Metallic Hg in contact with organic rich soils becomes soluble and eventually converts into its most toxic species, methyl mercury (MeHg), which rapidly bioaccumulates. Communities that rely on fish, especially carnivorous species, as a primary food source may be particularly susceptible to ingestion of dangerous levels of MeHg.

7. Metallic mercury, which is the main form of Hg released by ASM, is difficult to work with. The volatile state of Hg at ambient temperatures and the presence of other confounding anthropogenic sources of Hg, makes data interpretation difficult. Perhaps more importantly, the mechanisms governing the transformation of metallic Hg into its most toxic form, methyl mercury (MeHg), are not completely understood. When Environmental and Health Assessments (E&HA) are conducted to determine Hg exposure, geochemical and biological samples should be carefully chosen to fulfill the assessment objective. In most cases, limitations of resources and time often result in “short cuts” that can significantly impair data interpretation later on. Knowing that, the purpose of each monitoring step

must be defined clearly before starting any field activities. Proper design of monitoring programmes before entering the field is absolutely vital to establish the relevance and priorities for the sampling procedures.

B. Methodologies

Sampling fish for health risk assessment

8. To quantify potential Hg exposure to local, non-occupationally exposed people and determine the potential for health effects, the following information must be known:

- The daily average quantity of fish consumed (grams), for different meals
- The number of meals per day or per week that fish is consumed
- The relative proportion of different fish species consumed
- Size of the fish consumed
- The tissue Hg concentration of the target species consumed

9. Identifying the target fish species is the most important step in establishing the sampling protocol for the human Health Risk Assessment. Information on quantity and frequency of fish consumption of each target species can be best gained through interviews with the person responsible for preparing most of the meals, typically the women in the household. Alternatively, interviewing fishermen at the river banks or local fish shopkeepers will help identify the major species consumed and provide information on the relative abundance of the species captured. Because they are high on the food chain, carnivorous fish typically represent the main pathway of MeHg exposure to humans via dietary source. Akagi and Naganuma (2000) have also shown that the vast majority of Hg in herbivorous and detrivorous fish in the Amazon region is also in the form of MeHg.

10. There is a well-known positive correlation between fish size and mercury concentration in muscle tissue (Scot and Armstrong, 1972; Bodaly, et al., 1984; Somers and Jackson, 1993). Larger fish generally have higher Hg concentrations. To eliminate the bias associated with differences in fish size, Hg concentrations in fish must be measured over a wide size range. Then, appropriate statistical procedures are used to determine the mean Hg concentration for a specific fish size, usually near the size most frequently captured by consumers. This procedure should be followed to evaluate data based on standardized fish size. This will provide the health researcher with a methodology for following the evolution of Hg levels in fish over time.

Medical exam

11. A Health Assessment involves evaluation of the physical and mental conditions of individuals in order to characterize their health status and, in certain circumstances, to evaluate the possible influences of external factors that may or may not contribute to the aggravation of their health.

12. A medical exam consists of an initial questionnaire about the health history of the individuals, followed by a physical and neurological examination. Medical exams can be used to establish the levels of exposure to mercury. The specific methods for biomonitoring for mercury are found in Veiga and Baker (2004). Further, certain field tests can be performed to assess neurological function in order to characterize the neurological health of community members. These field tests are described in Veiga and Baker (2004). In some circumstances, with very carefully designed studies and sufficient population sizes to study, exposure and health data can be used to evaluate the relationship between levels of mercury in the body (based on analysis of hair, urine and blood) and neurological symptoms of mercury poisoning. It is strongly recommended that if such an epidemiological study is desired, that the study be designed in careful consultation with local health authorities and potentially local universities so that appropriate study design, standard protocols, sample size selection and analytical methods can be determined by scientists and researchers with experience in environmental epidemiology.

13. In any kind of medical screening, knowledge about socio-economic-demographic distribution and conditions of the individuals and their families is important, as factors in indicating, based on the routes of mercury exposure, the most susceptible and sensitive group of people in a community to be contaminated. Using a socio-economic-demographic study based on interviews it is possible to establish the characteristics of a mining community. All groups (young and senior miners, older and younger women, children, etc) should be represented and sampled in a proportion that represents a specific community.

14. In GMP studies, typically a minimum of 200 individuals in a mining community were recommended to be sampled and 50 in the control area, i.e. a community with similar cohort of people but not impacted by ASM activities. However, as mentioned earlier, appropriate study design, including sample size, should be determined based on the goals of the study, the particular levels of exposures and effects studied, background health status, presence of confounders, and other considerations; these decisions are best made in consultation with epidemiologists within local and national health authorities. ("Protocols for Environmental and Health Assessment of Mercury Released by Artisanal and Small-Scale Gold Miners" M. Veiga and R. Baker, 2004).

C. Case studies:

"Health assessment of artisanal gold miners in Indonesia"

15. An environmental and health assessment was performed in two regions of Indonesia (in Central Kalimantan and Northern Sulawesi). The environmental assessment showed severe mercury contamination and increased mercury levels in fish. For the health investigation, 281 volunteers were recruited and examined by a standardize questionnaire, a neurological examination and neuro-psychological tests. Mercury exposed workers showed typical symptoms of mercury intoxication, such as movement disorders. Blood, urine and hair samples were taken and analyzed for mercury. The mercury concentration in the biomonitors was high, partly extreme high in the working population, increased in the population living in the same habitat and low in the control group. By a standard protocol which includes a combination of threshold values of mercury in the biomonitors and a medical sum score the diagnosis of chronic mercury intoxication was made for highly burdened workers (amalgam smelters) in 55% of workers in Sulawesi and 65% in Kallimantan. Less exposed mineral processors and the general population in the mining areas were also intoxicated to a high percentage. (Bose-O'Reilly et al., 2009)

"Health Assessment of artisanal gold miners in Tanzania"

16. In 2003, UNIDO conducted and environmental and health assessment in a small-scale mining area in Tanzania. BGS (British Geological Survey) performed the environmental assessment. The Institute of Forensic Medicine-University of Munich performed the health assessment. The results of the examinations of 180 participants were analyzed to detect the level of mercury body burden. Mercury concentrations in the bio-monitors urine, blood and hair were statistically significantly higher in the exposed population compared to the control group. Only amalgam burners showed mercury levels above the toxicological threshold limits. A speciation of mercury in hair indicated that mainly elemental mercury vapor contributed to the high body burden of the artisanal miners. (Bose-O'Reilly et al., 2009)

D. Conclusion

17. Biomonitoring (hair and urine samples) and health assessment of miners and their families, people who live and/or work in close proximity to "gold shops" are useful methods to evaluate the health status of people in these communities. Health assessment and biomonitoring (hair samples) of persons in communities consuming those downstream fish should be conducted. Participation of the local health authorities is a pre-requisite for any biological sampling and plans should be made with these authorities for an appropriate follow up with the population.

18. Factors influencing the health of the artisanal and small-scale gold mining communities are numerous and inter-related. For this reason, undertaking extensive medical study of the impacts of mercury on health requires a sufficient sample size and a well-defined protocol.

19. Given the fact that mercury is a potent neurotoxin, a prudent public health approach can also focus on identifying populations at risk for exposure to mercury, and acting to reduce the pathways of exposures, while also working to reduce mercury emissions to the environment.

20. The level of exposure of a non-occupationally exposed population can also be estimated through sampling and analysis of key pathways such as food products, especially fish. In order to conduct such assessments, monitor mercury in fish tissue in fish caught downstream from mining areas is necessary.

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