Small-scale gold mining in developing countries can put the environment and human health at risk from mercury poisoning. **Don Appleton** explains how this contamination is being assessed.

Mercury contamination

Artisanal gold mining provides income to some of the world's poorest people, many of whom are women and children. But it is also one of the major sources of mercury contamination, especially in developing countries. Although the gold extraction process (known as amalgamation) is a simple technology, it is potentially very dangerous and contaminates the air, soil, rivers and lakes with mercury. The health of the miners and other people may be affected through inhalation of mercury vapour and through eating fish and other food contaminated with mercury. The Global Environmental Facility of the UN funds a Global Mercury Project that is currently being carried out by the United Nations Industrial Development Organisation (UNIDO) in six developing countries: Brazil, Indonesia, Laos, Sudan, Tanzania and Zimbabwe. The BGS was contracted by UNIDO to carry out environmental and human health assessments in the Rwamagasa small-scale gold mining area, in northern Tanzania. Scientists from the Geita Mines Office, the Tanzania Fisheries Research Institute (TAFIRI) and the University of Dar es Salaam assisted with the environmental assessment. The human health assessment was carried out by a team of medical experts from the Institute of Forensic Medicine, Ludwig-Maximillians University, Munich.

In the gold extraction process, rock containing gold is first ground in ball mills and then passed over sluices to separate the heavy mineral concentrates containing gold. These are mixed with mercury, which combines with gold grains to form amalgam. This is then separated from the heavy minerals by panning. The amalgam is then burned in a small charcoal fire to drive off the mercury and leave a gold pellet. Neither retorts, which condense the mercury vapour and prevent its escape, nor ventilation are used. Housing areas, food stalls and schools are located close to the sites where amalgamation and burning of the amalgam is carried out. In addition, mineral processing tailings contaminated with mercury are found within the village and adjacent to cultivated land.

About 12 kilograms of gold are produced annually in the Rwamagasa area, which results in the release of 12 to 24 kilograms of mercury to the atmosphere each year. Globally, at least 500 tonnes and possibly as much as 1000 tonnes of mercury is lost to the environment annually as a result of artisanal gold mining. This represents almost 30% of all anthropogenic sources of global mercury emissions.

The environmental assessment demonstrated that although the heavy mineral tailings are highly contaminated with mercury, dispersion of this material into the streams and on to agricultural soils appears to be quite restricted. Generally, low concentrations of mercury occurred in most of the analysed soils used for cassava, maize, and rice cultivation. Higher mercury levels in urban soils are probably caused by airborne transport and deposition of mercury released during the burning of amalgam. Although mercury concentrations are high in some vegetable plot soils, samples of vegetable, rice and maize collected from contaminated agricultural areas are generally very low in mercury. Fish are highly sensitive bio-indicators of mercury contamination. It is therefore not surprising that mercury in fish collected from contaminated ponds close to Rwamagasa exceeds the WHO recommended standard for protecting the health of vulnerable groups. The impact of mercury contamination on fish

Taking river sediment samples from the Malagarasi River, near Lake Tanganyika.

in the lower reaches of the Malagarasi River and the international waters of Lake Tanganyika, located about 400 kilometres downstream of Rwamagasa, is not readily discernible. This is probably because the extensive swamps located between Rwamagasa and Lake Tanganyika inhibit the dispersion of mercury.

Exposure estimates indicate that the local people should not be exposed to dangerous levels of mercury if they continue to eat fish from Lake Victoria and locally grown crops. However, consumption of fish caught in highly contaminated ponds in the immediate vicinity of the mineral processing centres should be avoided.

Nile perch from Lake Tanganyika.

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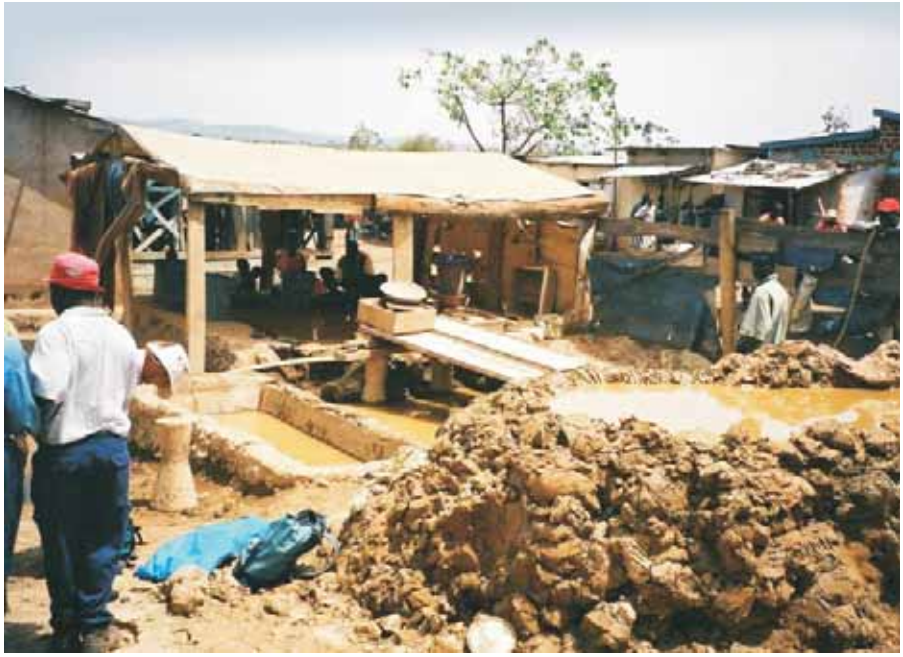
The health of 211 volunteers in the Rwamagasa artisanal gold mining area and 41 people from a nearby control area was assessed using state-of-the-art clinical, neurological, neuropsychological and toxicological tests. Mercury concentrations in samples of urine, blood and hair were significantly higher in the exposed population from Rwamagasa than in the control group. But only some amalgam burners showed mercury levels above the toxicological threshold limit in such samples. Mercury intoxication was diagnosed in 25% of the amalgam burners from Rwamagasa. In addition, intoxication was also detected in some people who had formerly worked with mercury and amalgam. Inorganic mercury from mercury vapour, rather than organic mercury from fish or agricultural crops, contributes to the high body burden of the artisanal miners.



Mercury amalgamation pond and sluices located in the centre of Rwamagasa.

Extremely high mercury concentrations were detected in two out of five breast-milk samples from nursing mothers who worked as amalgam burners. This is an important discovery because mercury can cause severe damage to the developing brain. The exposure of the whole community is reflected in raised mercury levels in the urine, and the detection of the first symptoms of brain damage such as loss of co-ordination, tremor and movement disorders. People from Rwamagasa who are not directly involved in amalgam burning have a higher mercury burden than the control group, although the majority of these people are not intoxicated. The mercury burden in the control group is of the same order of magnitude as in western industrial countries. Recommendations have been made to UNIDO regarding the reduction of mercury as an environmental and health hazard.

For further information contact:

Don Appleton, BGS Keyworth,
Tel: +44(0)115 936 3207
e-mail: jda@bgs.ac.uk

The Global Mercury Project website can be found at: www.unites.uqam.ca/gmf