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Building Capacity in Small-Scale Mining Communities: Health, Ecosystem Sustainability, and the Global Mercury Project

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Abstract: The Global Mercury Project (GMP) is an initiative of the United Nations in collaboration with numerous government and nongovernment organizations to promote knowledge and capacity building on the links between small-scale gold mining practices and health, ecosystem, and social factors, and to implement interventions that reduce mercury pollution and exposure caused by mining activities in developing countries. Knowledge regarding the use of mercury and the dynamics of complex environmental, health, socioeconomic, and cultural conditions in and surrounding small-scale mining sites is particularly needed for the purpose of developing appropriate community-based measures to reduce mercury-related problems. GMP strategies aim to build upon local knowledge and practices to train miners on the use of cleaner and affordable technologies of mining and mineral processing in order to minimize negative impacts. The initiative is especially proactive in facilitating transdisciplinary and participatory models of community interaction, involving local, regional, and international stakeholders in each of the strategy design, community assessment, and community intervention phases. The six participating countries are Brazil, Indonesia, Lao People's Democratic Republic, Sudan, Tanzania, and Zimbabwe. This article outlines GMP's objectives and scope of activities and also highlights achievements, challenges, and opportunities for future development.

Key words: capacity building, ecosystem approach to human health, mercury, artisanal and small-scale gold mining, Global Mercury Project

INTRODUCTION

Cycles of floods and drought, high prices of farm equipment, and an atmosphere of economic instability have driven millions of farmers in developing countries to abandon subsistence agriculture and take up artisanal mining, a practice which uses rudimentary techniques of mineral extraction and often operates under hazardous conditions. Driven significantly by poverty, artisanal and small-scale mining (ASM) is usually undertaken by workers with limited understanding of the long-term impacts of their activities on the environment and on their health and with limited capacity to mitigate the hazards. The terms artisanal mining and small-scale mining both refer to rudimentary processes of ore extraction and are referred to here as ASM. Ecological impacts caused by ASM activities include diversion of rivers, water siltation, landscape degradation, deforestation, destruction of aquatic habitat, and mercury pollution (Mol and Ouboter, 2004). Direct

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impacts of ASM on human health can include acute mercury poisoning, silicosis, neurological and kidney damage, cardiovascular and respiratory dysfunctions, as well as injury and fatality from landslides, cave-ins, and chronic physical overexertion (Hinton et al., 2003a).

Despite the risks of working in tunnels with explosives and being exposed to mercury, cyanide and other toxins, ASM provides a primary source of earnings for a rapidly growing number of people around the world, particularly in regions of Africa, Asia, and Latin America where alternative sources of income are limited. According to the International Labour Organization, the number of artisanal and small-scale miners worldwide increased by up to 20% between 1989 and 1999 (ILO, 1999). Recent assessments put forward by the United Nations Industrial Development Organization (UNIDO) indicate that there are as many as 20–30 million small-scale miners in more than 55 countries, roughly equivalent to the global workforce of large-scale mining. It is estimated that 80–100 million people worldwide are directly and indirectly dependent on ASM for their livelihood (Veiga and Baker, 2004). As this population continues to increase due to a combination of rising gold prices and widespread unemployment in poorer countries, there is an urgent need to develop the capacity of artisanal and small-scale miners to minimize the risks associated with their mining practices, and promote safer, cleaner, and more sustainable modes of operation.

In 2002, the United Nations launched a new initiative, called the Global Mercury Project (GMP), aimed at removing barriers to the adoption of cleaner practices of small-scale gold mining. Convinced that the health and ecosystem impacts in mining areas require an integrated approach, the project sought to provide a platform upon which knowledge gaps in the complex interrelationships among social and environmental factors could be addressed. In particular, it was envisaged that the GMP would spearhead the search for opportunities to reduce negative health and ecological impacts caused by mining through a series of multi-stakeholder consultation processes and capacity-building campaigns in affected communities. Partnering with government ministries, local authorities, health organizations, and miner associations, the project undertook assessments of health, ecological, social, economic, and technological factors in participating communities. This knowledge, it was hoped, could be effectively utilized to design and implement intervention strategies that target the causes of poor practice, ill health, and pollution.

This article has two purposes: (1) to introduce the GMP to a wider audience of researchers with the aim of stimulating mutual exploration of transdisciplinary approaches in global capacity-building; and (2) to review the project's achievements and challenges for the first period (2002–2005), drawing attention to the opportunities of an ecosystem approach to human health in linking crucial elements for future phases of development.

Ecohealth Impacts of ASM and the Development of a Global Initiative

Given the informality and unregulated nature of many ASM operations throughout the world, the full extent of this activity and its ecological and health impacts are difficult to determine. As gold is easily sold and traded in markets that are not dependent on the stability of local governments, it is by far the most important mineral extracted by ASM in developing countries. The number of artisanal and small-scale gold miners alone is estimated at 10–15 million people, including 4.5 million women and 300,000 children (Veiga and Baker, 2004). Because mercury amalgamation is simple and inexpensive, it is the gold concentration method most used in ASM. As a consequence of its misuse, mercury amalgamation results in the discharge of an estimated 1000 tons of mercury per annum into the ecosystems of developing countries (Veiga and Baker, 2004).

Mercury misuse in ASM has generated thousands of polluted sites with impacts extending far beyond localized ecological degradation, often presenting a serious, long-term health risk to individuals residing in mining regions. Amalgamation employs metallic mercury to trap fine gold, with mercury often being discharged with contaminated tailings and/or volatilized into the atmosphere. The usual practice is to burn the amalgam in a pan or shovel in open air bonfires, with the inhalation of mercury vapor posing a serious health risk. Due to inefficient techniques, in many regions in Latin America and Africa, an estimated 2 g of mercury are released into the environment for each gram of gold recovered (Veiga and Baker, 2005) although these estimates can vary from region to region. Metallic mercury is also transformed into methylmercury in aquatic systems, which becomes biomagnified in the food chain. Local communities reliant on fish, especially carnivorous fish, as a primary food source are particularly susceptible to accumulation of high levels of methylmercury and to

neurological damage in cases of acute intoxication (Ikinguara and Akagi, 1996; Mergler 2002; Webb et al., 2004). Methylmercury can also cause sterility and is easily transferred from pregnant women to their fetuses, with effects ranging from spontaneous abortion to neurological symptoms in the child (WHO, 1990).

In 1990, UNIDO began coordinating international efforts to provide technical assistance to small-scale miners, promoting the replacement of low gold recovery, high mercury consuming and discharging practices with more environmentally sound and high-yield gold extraction alternatives. Following a gold rush in developing countries in the 1980s and early 1990s, a consensus emerged among experts in the field that both regulatory (top-down) and community capacity-building (bottom-up) strategies needed to be pursued. Working with governments and community stakeholders from Venezuela, Ghana, and the Philippines, UNIDO carried out programs to develop local capacity to assess and minimize mercury emissions caused by mining and provide high-level technical advice to government officials to design regulations and institutional reforms. In 2001, with financial assistance from the Global Environment Facility (GEF), UNIDO identified hot spots with the potential for affecting international waters due to especially high levels of mercury pollution in streams and rivers. These efforts culminated in the solidification in August 2002 of a longer-term initiative, the GMP, supported by GEF, the United Nations Development Program (UNDP), and UNIDO, to demonstrate ways of overcoming barriers to the adoption of strategies that limit mercury emissions in ASM.

Scope of GMP Activities

Six countries are currently participating in the GMP, each possessing diverse ecosystems: Brazil (Amazon), Lao PDR (Mekong), Indonesia (marine environment), Sudan (Nile), Tanzania (Lake Tanganyika), and Zimbabwe (Zambezi). The project is complemented by a suite of ongoing activities that are supported through participating countries' resources and/or bilateral programs (Veiga and Baker, 2004). As a capacity-building initiative that combines expertise in mining engineering, health promotion, economic development, and environmental planning areas, the GMP seeks to provide a strong link between researchers and practitioners to implement solutions. The specific goals are: (1) to reduce mercury pollution of international waters by emissions emanating from small-scale gold mining; (2) to introduce safer and cleaner technologies for gold extraction and to train people in their application; (3) to develop capacity as well as the policy, regulatory, and economic mechanisms that will enable the sector to minimize mercury pollution; (4) to introduce environmental and health monitoring programs; and (5) to build capacity of local laboratories to assess the extent and impact of mercury pollution.

The countries participating in the GMP were selected based on the importance of ASM to their populations, preliminary assessments of mercury use, and support of the national and regional governments for capacity-building activities. Another important factor was the potential of international waters to be impacted by mercury from mining. Most ASM activities within the six GMP countries are conducted within river basins of major ecological significance and which cross geographical boundaries (e.g., basins of the Amazon, Nile, Lake Tanganyika, Zambezi River, and Mekong River). The negative environmental impacts of ASM activities therefore have the potential to affect not only the countries where mining is conducted, but also other countries ''downstream'' in the river basin. Gold mining activities in Brazil discharge nearly 40 tons of mercury annually, with significant pollution risks to the Amazon Basin, the largest drainage system in the world which also constitutes the largest reserve of biological resources. Nearly 150 tons of mercury is discharged annually into the environment in Indonesia, affecting the Java Sea and nearby waters (Veiga and Baker, 2004). Little investigation had been previously undertaken to address the mobility of mercury emanating from small-scale mining through international waters. The GMP represents the first effort to implement a global assessment and action plan.

Following its launch, the GMP conducted exhaustive consultations with stakeholders to formulate an appropriate community assessment and capacity-building agenda (Table 1). These reinforced the widely held view that implementation of technical solutions required detailed knowledge of the cultural, social, economic, and organizational context on a site-specific basis in addition to a thorough understanding of mercury exposure pathways and mobility through the diverse ecosystems. Numerous studies have noted that a major barrier to the adoption of cleaner mining practices is that the impacts of mercury misuse are complex and difficult to see immediately, thus masking the dangers (Hilson, 2002a; Hinton et al., 2003b). Another significant barrier is that many small-scale miners

Table 1. Summary of Milestones during the GMP Assessment and Stakeholder Consultation Process[a]

April 2002	Launching of GMP
June–September 2003	Sociological surveys of miners in project sites
October–December 2003	Development of technical and socioeconomic profiles of project sites
January–March 2004	Development of the GMP protocols for environmental and health assessments of mercury released by ASM
March–May 2004	Training of regionally-based public health practitioners
May 2004–May 2005	Integrated health and environmental assessments in project sites
June–December 2004	Studies on national and international legal and policy aspects ASM
March–May 2004	Development of training curricula and identification of appropriate equipment for community training and demonstrations in each project site
May–October 2005	International workshops on the GMP Technology Demonstration, Training, Education, and Policy Development Campaigns (in all six countries)
October 2005–December 2006	Studies and stakeholder consultations to promote the development of micro-credit for small-scale miners
October 2005–December 2006	Analysis of international mercury mobility through satellite imaging
October 2005–December 2006	Implementation of GMP Technology Demonstration, Training, Education, and Policy Development Campaigns in target communities (in all six countries)

GMP, Global Mercury Project; ASM, artisanal and small-scale mining.
[a]Each assessment was, or will be, conducted by a selected team of experts, combining local expertise with international researchers as appropriate.

are unaware of cost-effective ways to eliminate the hazards. Recognizing these barriers as nuanced and widespread, the participants generally agreed that, to develop effective site-specific training programs, a variety of expertise was needed to create synergy in the process. As well, sociological surveys conducted by teams of United Nations and local researchers enabled communities to describe their customs, share their knowledge on social, environmental and health aspects in the area, and provide feedback on the project before further assessments and training programs were undertaken (GMP Sociological Reports, 2004).

Information on the effects of mercury on human health exists but is inadequately disseminated in developing countries (Hilson, 2002b). A key early accomplishment of the GMP was the training of a cadre of regionally-based public health personnel in the assessment of clinical signs and symptoms of mercury poisoning and methods of improving environmental health in mining areas. In each country, these partnerships were strengthened while integrated health and environmental assessments were conducted in the project sites, using GMP protocols that provided a framework for combining biogeochemical, sociodemographic, and technical analyses (Veiga and Baker, 2004). Results showed that symptoms of mercury intoxication are especially widespread in miners in Zimbabwe, Indonesia, Brazil, and Tanzania, with alarmingly high levels of intoxication found in miners in all six countries who spent significant amounts of time burning mercury amalgams. Neurological disturbances such as ataxia, tremors, and coordination problems were found to be common among this group. In Kadoma, the main project site in Zimbabwe, 70% of miners (69% of child miners) were intoxicated, many of whom appeared to be suffering from tremors, a typical sign of mercury-induced central nervous system damage. With extremely high mercury concentrations in breast-milk samples from nursing mothers in GMP communities, infants are especially at risk. In addition to problems from mercury vapour, the assessments found that mercury methylation is a severe ecosystem hazard in project sites in Brazil, Indonesia, and Zimbabwe, with particularly harmful impacts on the fish-eating communities where mercury accumulates in aquatic biota. The Environmental and Health Assessments in each country were conducted by different research teams, following the protocols of the Global Mercury Project (Veiga and Baker, 2004), and are posted on the GMP website, http://www.globalmercury.org.

Technical and socioeconomic studies in all participating communities assessed current equipment and practices, needs of the miners, and accessibility of new equipment. In all GMP communities except those in Brazil, women and children engage in open-air mercury amalgamation at

home, with entire families exposed to mercury vapour. Combined use of mercury and cyanide in mineral concentration was also identified as particularly dangerous and widespread, and practices that involve the amalgamation of whole ore (all the ore mined) also caused excessive amounts of mercury to be used and leaked into the surrounding soils and streams. Correlations between specific mining techniques and negative health and ecological impacts have begun to be compiled by the project, constituting a valuable area for further investigation that can help guide future training as well as regulatory policy.

Between May and October 2005, a series of international workshops was held in all six countries to determine how to transfer knowledge effectively from the assessments into the community intervention phase of the project. This phase focuses on capacity building—training and demonstrating solutions to miners, families, and authorities—with emphasis on implementation of affordable and easily accessible ''homemade'' equipment, such as amalgamation retorts (made of metal or glass kitchen-bowls) which contain mercury vapour and decrease mercury use in the amalgamation process (Babut et al., 2003). During this phase, GMP efforts aim to reduce mercury use and promote safer, healthier, and more cost-effective mining practices; strengthen community organization; improve access to equipment through micro-finance programs; enhance participation of miners in environmental planning processes; and assist authorities in the implementation of needed regulations and reforms.

Capacity Building: An Ecosystem Approach to Health

Due to the importance of amalgamation to the ASM process and their immediate livelihood, convincing miners to eliminate mercury use because of health hazards is difficult. Particularly in the case of Africa, lack of sanitation, widespread infectious diseases, and limited access to health care have resulted in generally poor health conditions in ASM communities, such that any program directed exclusively at reducing the comparatively invisible health impacts from mercury is hard-pressed to garner local interest. As such, the capacity building approach adopted by the GMP does not focus on mercury issues alone, but rather on the myriad of intertwined health, environmental, and socioeconomic challenges in these communities. An ecosystem approach to human health is emphasized as a way to build on the growing understanding of interrelationships among factors that produce ill health and ecosystem disruption and affect the feasibility of building sustainable ways to prevent and control these risks (Forget and Lebel, 2001; Mergler 2003, Rapport and Mergler, 2004). This approach focuses, above all, on the inextricable links between humans and their biophysical and social environments and is based on three methodological pillars: transdisciplinarity, participation, and equity (Lebel, 2003), each pivotal in the GMP action plans for capacity-building.

Transdisciplinarity refers to collaboration by researchers and practitioners from complementary disciplines through a process that allows them to exceed their own discipline to generate new logical frameworks, new methods, and new institutions born from the synergy that ensues from this collaboration (Lebel, 2003; Dakubo, 2004). It is worth noting that previous projects on mercury management in developing countries have tended to adopt frameworks based on hazard awareness, technical training *or* regulatory changes, with short-term agendas and limited resources for integrating multiple disciplines and strategies (Hilson, 2002a, 2005). Moreover, authorities have tended not to combine health and environmental planning processes in mine sites and are often unfamiliar with ways to support educational programs on the ground (Hinton et al., 2003a,b). Seeking to better connect miners, field practitioners, experts and authorities, the GMP model involves team members with diverse expertise in community development disciplines to bridge diagnostic, risk communication, and knowledge translation models. The collaboration to build sustainable solutions through a transdisciplinary approach proved critical in developing the GMP community training curriculum (Table 2), which recognizes that each community faces different challenges and that the need to alleviate poverty and address malaria and HIV/AIDS is primary in many GMP communities where mercury pollution is also a problem. The project's multi-faceted training curriculum is designed to remove barriers to the adoption of cleaner practices by demonstrating ways of reducing mercury hazards as well as other occupational health and environmental problems, improving miners' income through better gold recoveries, implementing disease mitigation and health care measures (vaccinations, HIV/AIDS prevention controls, prenatal and postnatal care, etc.), and improving sanitation and management of waters—stimulating awareness of the interconnectedness of these issues and how solutions can be realized.

Table 2. GMP Education and Training Program in Small-Scale Mining Communities: Modules for the Train-the-Trainer Process[a]

Training modules	Knowledge from community practice	Knowledge from academic discipline
Module 1: how to produce more gold	Underground mining methods: winches; windlasses; wheelbarrows; dewatering	Mining Engineering
	Mine safety: ground stability; ventilation; timbering; personal protective equipment	Mining Engineering; Occupational Health and Safety
	Alluvial mining methods: control of siltation; gravity concentration	Mining and Mineral Processing Engineering; Watershed Management
	Mineral processing methods: liberation and concentration of gold; crushing and grinding; gravity concentration; safe extraction with mercury	Mineral Processing Engineering
Module 2: how mercury makes us sick	Pathways of exposure—metal and methylmercury: vapor; skin; ingestion	Environmental Toxicology
	How to recognize symptoms	Healthcare
	Effects on children and women (especially pregnant women)	Epidemiology; Gender Studies
Module 3: how to use and re-use mercury safely	Safe extraction of gold from concentrate: amalgamate concentrate—not whole ore; use amalgamation barrels; properly dispose of amalgamation tailings	Mineral Processing Engineering; Occupational Hygiene
	Burning amalgam in retorts to contain vapor (outdoors and away from houses)	Mineral Processing; Occupational Hygiene
Module 4: how to make more money	Participating in the formal economy: how to become a legal miner; how to secure mineral rights	Law; Economics; Sociology
	Managing money: double-entry bookkeeping	Business; Accounting
	Selling gold for a better price: government and cooperative gold buying/marketing schemes	Economic Policy
	How to access more efficient equipment: micro credit and renting	Economics; Business
	Alternate forms of organization: how to form cooperatives and partnerships	Business; Accounting; Political Science
Module 5: how to protect water supplies and improve sanitation	How mercury behaves in water: siltation and mercury transport; bioavailability of metal mercury; methylmercury	Hydrology; Toxicology; Chemistry
	How to manage animal and human waste: bacteria and parasites; how to build toilets	Water and Sanitation Engineering
	How to access clean drinking water: hydrological cycle; the water table; rainwater management	Hydrogeology; Integrated Watershed Management
	How to manage mining waste: tailings impoundment; reclamation	Environmental Policy; Civil Engineering; Agricultural Science
Module 6: how to prevent HIV/AIDS, malaria, and other diseases	Prevention of HIV/AIDS transmission: condom use; empowerment of women; safe use of scarification implements	Healthcare; Epidemiology; Gender Studies; Anthropology
	Malaria: use of netting and other preventative measures; how and where to obtain treatment	Healthcare; Epidemiology
	Mercury poisoning, tuberculosis, and other diseases	Healthcare; Toxicology

[a]GMP experts have (or in some cases will) use these modules to train local mining and public health personnel who will then lead the majority of community training activities.

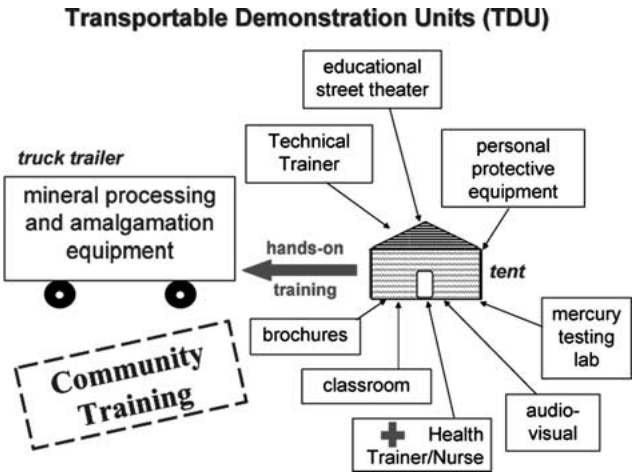

Figure 1. Global Mercury Project training units.

Training will also encourage strengthening community organization to legalize miners who do not currently possess land rights and to adopt changes collectively. *Participation*, a second pillar of the ecosystem approach to human health, is fundamental to enable affected populations to initiate solutions in a way that can be sustainable and maximize limited resources. The first phase of the GMP emphasized participatory processes in developing capacity-building models that are country-specific and community-specific, wherein community members identified what equipment is needed most and what techniques should be demonstrated. The second phase of the project seeks to involve as many community members as possible in the training workshops and to encourage participation of new players. To reach broad audiences, communication methods were locally determined to build upon the cultural roots and institutional strengths of the communities, such as using soccer events, music, street theater, and circuses to attract people to training workshops; education events at schools and through religious organization; and radio and television campaigns to promote awareness of mining issues as well as GMP activities.

Enhancing participation is especially vital throughout the implementation of the Transportable Demonstration Units (TDUs), which provide platforms for community training on improved technological options for mining and mineral processing, as well as environmental health and safety (Fig. 1). Parallel to the activities of the TDU education center, media campaigns are designed to draw people to these events and address the critical misperception that mercury is not dangerous because, like HIV/AIDS, its toxic effects are not immediate. GMP participants noted that the success of many previous training initiatives was limited because they relied upon permanent, immobile structures for technological demonstrations which were not adaptable to new locations and thus restricted participation. In view of these lessons and the fact that artisanal miners are typically mobile and transient, the GMP mobile units were designed to travel to different highly-populated zones to maximize community participation and bring solutions to miners where they work.

Observations made throughout the work of the GMP led to the conclusion that *equity*, a third pillar of the ecosystem approach to health, also needed to be a benchmark in the development of GMP strategies to address disproportionate burdens in especially vulnerable segments of communities. In particular, the consultation processes revealed that gender-specific approaches are indispensable. The recognition of the important role of women in ASM has taken on considerable importance as more than 30% of the world's artisanal miners are women, the majority of whom work in the mineral processing aspect—including amalgamation with mercury (Hinton, 2003). As women are also predominantly responsible for food preparation, they are in an excellent position to address health risks associated with consumption of mercury-contaminated foods. Because women are often associated with transporting and processing materials as opposed to digging, they are not always identified as ''miners'' (Sasapu and Crispin, 2001; Hinton et al. 2003a), and thus there is an especially important need to promote the inclusion of women in community planning processes at miner association workshops and other venues. GMP efforts will focus on training women specifically, reducing exposure risks to women (especially pregnant women) and their families, and promoting gender equity in community planning.

GMP field work also established that an important component of equity relates to power differences among the stakeholders involved in gold and mercury circulation. In many ASM communities in Zimbabwe, Brazil, and Tanzania, those who buy the gold and/or sell mercury to the miners (so-called middle-men) also own and control the only accessible mineral processing centers in the area and thus hold great influence over the practices of the miners. Understanding these sensitive social dynamics is important to develop effective ways to promote change. In the short term, the GMP team will organize workshops with miners and milling center operators alike to promote mutually desirable and

efficient ways of eliminating health and ecological hazards. The TDUs, while empowering miners to improve their practices individually, will also serve as forums in which community members can collectively plan safer, cleaner, and more cost-effective practices through equipment-sharing and revenue-sharing arrangements. Although attempts to create formal business cooperatives had generally not been made in mining in the participating countries, this kind of approach may also prove valuable in a number of communities where individuals have little money to invest in equipment and currently receive exceptionally low prices for their gold.

Challenges and Future Priorities

ASM is often characterized by extensive negative environmental, health, and socioeconomic impacts. However, ASM also provides livelihoods for a growing number of people in developing countries around the world. With little or no investment capital or technical knowledge, miners are in great need of resources to help them minimize the negative impacts of their livelihoods. Where alternate economic strategies are viable, these must also be pursued. Worldwide awareness of health and environmental problems and the growing number of children involved in ASM, combined with the reality that mercury contamination crosses national boundaries, has led to much needed international collaboration. Simple technological solutions now exist that can reduce mercury exposure while promoting more cost-effective operations. However, there are several major challenges to their implementation; chief among these is that controlling mercury emissions requires addressing the driving forces and pressures that have been barriers—including poverty and disease. Linking experts from different disciplines to create common frameworks for hazard reduction is clearly needed. Since the artisanal mining sector in developing countries has seen few examples of long-term community-based efforts combining biomedical, technical, sociological, economic, and cultural aspects, new and positive examples are greatly needed.

Another challenge is that governments where ASM is widespread have limited resources, and top-down initiatives based on regulatory approaches have limited application and effectiveness, especially due to widespread illegal mercury markets and mining activities. Bottom-up initiatives based on participation and cooperation between miners, government, and nongovernmental agencies offer greater promise for community impact. Recognizing the need for synergy between policymaking and practice, the GMP is encouraging the involvement of local inspectors in training workshops along with leaders of mining groups. Through the GMP, the United Nations has opened up numerous collaborative opportunities, embracing an ecosystem approach to address these challenges. Alliances with new donors and partners, including the private sector, could further reinforce these global efforts. The GMP is committed to careful monitoring of the effectiveness of the proposed interventions, especially in terms of the impact on health, ecology, and economies of local communities. Finally, the GMP's growing emphasis on the role of transdisciplinary, participatory, and equity-focused initiatives, is likely to generate valuable insights and lessons for other ecohealth research and projects that seek to integrate health, ecological, and economic concerns in community development.

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