

Contaminated identities: Mercury and marginalization in Ghana's artisanal mining sector

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Abstract

This article provides a counter-narrative to the dominant discourse of marginalization and criminalization of Ghana's illegal gold miners (*galamsey*) by focusing on the contested mercury debate. We first examine the complex and multifaceted policy problem that underlies the current conflictual aspects in the small-scale mining sector, arguing that mercury use and contamination are key elements in the anti-galamsey rhetoric. Second, we describe an interdisciplinary pilot study on human and environmental health that involved health personnel and illegal miners from two sites. Through participatory ranking and mapping activities, we explored participants' understanding of mercury and other life hazards as well as causes and consequences of mercury contamination. We used chemical indicator strips to sample contaminated areas in collaboration with the miners. By drawing upon novel concepts from the environmental justice and ecohealth literature, we propose a political ecology of human and environmental health that advocates recognition of *galamsey* operators and their participation in learning opportunities as a first step out of the current impasse in the Ghanaian small-scale mining sector.

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1. Introduction

Artisanal and small-scale mining (ASM) in developing countries is a largely poverty-driven activity. ASM is a practice that involves rudimentary techniques of mineral extraction, highly manual processes, hazardous working conditions, and frequently negative human and environmental health impacts (Hilson, 2002). An estimated 80–100 million people worldwide are currently engaged in this industry and directly or indirectly depend on it for their livelihood (Veiga and Baker, 2004). While ASM has the potential to contribute to poverty reduction, it often perpetuates poverty through high sensitivity to physical

hazards, illness, and accidents, and lack of knowledge about more efficient, safer, and environmentally friendly techniques. These factors tend to keep miners trapped in a vicious cycle of poverty and vulnerability (Heemskerk, 2005; Sinding, 2005).

In Ghana, ASM, mostly of gold, has expanded dramatically in recent years. The country is currently Africa's second largest gold producer after South Africa, with gold exports accounting for >40% of total export earnings (Mate, 1999, in Carson et al., 2005). Over the past ten decades, Ghanaian gold production from ASM activities has risen tenfold and doubled since 1998 (Table 1), accounting for an estimated contribution of \$461.1 million to the national economy since 1989 (Carson et al., 2005). Between 300,000 and 500,000 people are currently involved in small-scale gold extraction, which amounts to roughly two thirds of Ghana's total gold miners (Carson et al., 2005; Ryan, 2006). Hilson and Potter (2003) estimate that half of those employed in

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Table 1
Small-scale mining, Ghana

Year	Sales (\$ millions)	Ounces	% Small-scale mining in total Ghana
1989	3.4	9272	2.2
1990	6.3	17,233	3.2
1991	5.3	15,601	1.8
1992	6.1	17,297	1.7
1993	11.5	35,144	2.8
1994	34.7	89,520	6.2
1995	48.7	127,025	7.4
1996	36.0	112,349	7.1
1997	28.4	107,094	5.9
1998	36.6	128,334	5.4
1999	35.2	130,833	5.2
2000	40.9	145,662	6.2
2001	39.3	185,596	8.7
2002	48.9	160,879	7.2
2003	79.8	211,414	9.5
Total	461.1	1,593,253	

Sources: Amankwah and Anim-Sackey (2004) and Yakubu (2002).

the sector are women, one of the highest rates in Africa. Women typically work as panners, carriers, and processors as well as jewelry makers, cooks, and other service providers (including prostitutes) in and around mining sites.

As Ghana's per capita income (GDP) is \$434 and the unemployment rate for the 15–24 age group has reached a national average of 30% (in mining areas 70–90%), ASM provides a vital source of income to tens of thousands of people who have few means for survival in the formal economy (Carson et al., 2005). Most men and women engaged in the ASM sector are farmers and miners who have lost land to large-scale, multinational mining corporations. High unemployment rates in urban areas explain the rising number of former professionals, semi-skilled laborers, and university graduates now found in the ASM mining sector (Hilson and Potter, 2005).

Despite the state's official policy to promote small-scale mining as a catalyst for poverty reduction and sustainable development (Aryee, 2003) and various attempts to regularize the sector through a series of laws and enactments, illegal mining in Ghana continues to be widespread. According to Carson et al. (2005), roughly 85% of the total labor force operate without an official license. Locally, these miners are referred to as *galamsey*, a term that originated from the phrase 'gather and sell' (Rimbaud et al., 2000). In practical terms, there are few differences organizationally or technologically between unregistered illegal and registered small-scale miners, with the exception that the latter have security of tenure, or legal entitlement to work a plot of land (Carson et al., 2005). Illegal small-scale mining is certainly not restricted to Ghana. According to the International Labor Organization (ILO, 1999), up to 80% of small-scale miners worldwide operate without formal authorization. The main reasons for the high number of illegal operators are land scarcity for small-scale mining under rapid demarcation of land for large-scale companies,

high transactions costs involved in obtaining a license, and the non-transferability of mining rights (Sinding, 2005; Andrew, 2003; Hilson and Potter, 2003).

The livelihood opportunities in ASM notwithstanding, *galamsey* activities in Ghana have become increasingly contested. As in many resource-rich developing countries, land use disputes are pervasive, although rarely the only trigger for conflict (Andrew, 2003). In their study on conflict mitigation in Ghana's gold mining, Carson et al. (2005) outline conflictual dimensions of *galamsey* operations around four axes: (1) encroachment on companies' concessions and pilfering of gold ore and equipment; (2) environmental degradation from the use of mercury in the gold extraction process and lack of rehabilitation of disturbed land surfaces; (3) social disruption due to the temporary and migratory nature of their work, including increased drug use, alcohol abuse, prostitution, communicable diseases (e.g., HIV/AIDS), school drop-outs, and rivalries and conflicts; and (4) the militarization of some *galamsey* groups due to a growing inflow of firearms.

In public and governmental discourse and the Ghanaian media, *galamsey* miners have been portrayed as a 'headache', 'challenge', 'problem', 'menace', and 'threat', whose presence necessitates the implementation of a 'lasting solution' (Ghana Web, 2004; Reuters, 2006; Mining News, 2006; General News, 2006; Regional News, 2006). Non-miners in mining towns perceive the *galamsey* as criminals and reckless polluters of drinking water and other natural resources, the latter mainly because of the use of mercury in the gold amalgamation process. In the environmental narrative of small-scale gold mining in Ghana, illegal miners have become the 'villains' in the cast of actors (Roe, 1991; Adger et al., 2001). Concession holders stripped of their entitled minerals and profits and farmers who have lost their productive land are seen as 'victims' while governmental agencies, mainly police and military forces cracking down on illicit activities, stage as 'heroes' in this increasingly heated debate.

The main purpose of this article is to challenge the dominant anti-*galamsey* discourse by reassessing the mercury debate from a miner's perspective. This is a novel approach as public, scientific, and governmental discourses alike have denied the *galamsey* a 'place at the table' to address contamination and injustice. The article is divided into two parts. First, we use a political ecology framework to assess the complex and multifaceted policy problem that underlies the current conflictual aspects of the ASM sector, with particular focus on mercury pollution. We argue that mercury use and contamination are key elements in the anti-*galamsey* rhetoric of marginalization and criminalization in Ghana. We contend that inadequate governmental policies, technological failures, and an ignorance of community dynamics in the ASM sector have all contributed to a unique case of environmental injustice that has prevented miners from participating in educational activities that explore and promote more environmentally friendly techniques.

Second, we describe an interdisciplinary pilot study conducted in August 2006 that sought to include *galamsey* in the assessment of mercury and other life hazards, drawing upon the ecosystem approach to health, known as ecohealth (Lebel, 2003). Research was carried out at two sites located in the heart of the Ghanaian gold belt in the south-western part of the country. By using a mixed and participatory methods approach, we assessed the daily hazards of men and women miners, explored participants' understanding of the causes and consequences of mercury contamination for human and environmental health, and identified and measured mercury contamination in drinking water in collaboration with the miners. Finally, we propose to extend the theoretical boundaries of political ecology by integrating novel ideas from the environmental justice debate and the ecohealth approach. We conclude with recommendations for more community involvement to build local capacity for enhanced human and environmental health in the ASM sector.

2. Marginalization and contamination in Ghana's artisanal gold mining

2.1. The political ecology of *galamsey* marginalization

Political ecology typically addresses unequal power relations regarding access to and control over resources, the reflection of such power relations in discourses and knowledge claims about the environment and development, and resistance and opposition to unequal social–environmental dynamics. The dominant environmental discourse of mercury contamination, as outlined for small-scale gold mining in Ghana, invokes growing numbers of illegal miners who irresponsibly use mercury to extract gold, thereby wrecking the environment and endangering their own and other people's health. This section discusses the socio-political dimensions of the dominant anti-*galamsey* discourse and assesses how condemning, marginalizing, and criminalizing these unregistered miners shapes environmental injustice in the ASM sector.

With the 1989 Small-Scale Gold Mining Law (PNDCL¹ 218), the Mercury Law (PNDCL 217)² and the PNDCL Law 219,³ the government of Ghana has legalized small-scale gold mining and provided a broad regulatory framework for gold processing and marketing. Yet, many governmental officials continue to regard the ASM sector in general and illegal mining in particular as 'a major impediment to the development and financing of large-scale mines' (Hilson and Potter, 2005, p. 114). The state pursues various modes of marginalization that are in stark contrast to the official rhetoric of poverty reduction.

¹ PNDCL: Provisional National Defense Council.

² PNDCL 217 allows small-scale operators to purchase mercury from licensed mercury dealers.

³ PNDCL 219 regulates purchasing services for small-scale gold (and diamond) miners through the Precious Minerals Marketing Corporation.

Inadequate governmental policies toward the ASM sector and weak structures of governance, as outlined by Carson et al. (2005), constitute the principal form of marginalization. In essence, the state has turned traditional ASM into an illicit activity by leasing large areas of land to large-scale corporations and requiring small-scale operators to undergo a lengthy registration process for the few remaining suitable areas, a trend also observed in other developing countries (Andrew, 2003). Through insufficient institutional, technical, and educational support, accredited governmental agencies proliferate the mercury pollution problem in the ASM sector, which then serves as additional evidence of miners as reckless environmental stewards, further reinforcing social and political subjugation. Other forms of marginalization include dispossession of lands, relocation of communities, inadequate compensation, exclusion from decision-making processes and fair prices from mining activities, and lack of support for alternative job opportunities, especially for women (Ballard and Banks, 2003). We now briefly discuss the main elements of marginalization that shape the character of the *galamsey* industry in Ghana.

First, the Ghanaian Minerals and Mining Law (PNDCL 153) originated in the mid-1980s during the period of the Economic Recovery Plan whose main goal was to revitalize the country's stagnating economy through private investment (Hilson, 2001). Large areas of land in the mineral-rich southwestern part of the country were demarcated for large-scale gold mining companies. Indigenous landowners, whose lands were leased out by the government, generally did not receive alternative lands to farm or mine when they were resettled (Carson et al., 2005). In areas where corporations clash with local communities, walking to farm lands has become dangerous, as reported by participants in this study.

Second, those miners who seek official registration encounter a series of bureaucratic and procedural hurdles. Registration can take 6–8 months (Hilson and Potter, 2003) or, as claimed by miners in this study, up to 1 year. In addition to the required paperwork and fees with the Environmental Protection Agency, the District Assembly requests 20 million Cedi⁴ as a flat rate for the first year and 5 million Cedi for each subsequent year. Given the few unoccupied areas, inadequate geo-prospecting, and no guarantee for long-term exploitation, many small-scale operators forgo seeking a formal title and instead work without it, illegally. A further disincentive for registration is the fact that illegal miners can openly sell their gold to buying agents licensed through the Precious Mineral Marketing Corporation (Hilson and Potter, 2003).

Third, recent attempts of cooperative large-scale companies to cede parcels of unexploited land to artisanal miners are now undermined by the Minerals Commission (MC)

⁴ In August 2006, 20 million cedi equaled \$2240 (exchange rate \$1 = 9424 Cedi).

(Carson et al., 2005). It is speculated that the MC prefers selling promising land to a well-paying investor rather than making it available for licensing to ASM for an unattractive fee.

Finally, institutional support for the ASM sector has been gradually shrinking. The MC, the main regulatory and promotional agency in Ghana's mineral sector, is now the only governmental institution working on small-scale mining. It lacks the necessary human and financial resources to service small-scale operators; its seven small-scale mining district support centers that register claims, provide technical advice, and organize training sessions are under-funded, and access to finances to lend to miners is scarce (Hilson and Potter, 2005). This is coupled with inadequate understanding of local conditions and resources for effective community partnerships (Carson et al., 2005). These institutional constraints not only provide insufficient incentives for miners to register and work legally, but also preclude the large majority of them from engaging in more environmentally safe practices.

The *galamsey* struggle over access to and control over productive land while their resistance to state marginalization is fueled by a sense of moral injustice and desperation to meet livelihood needs. Their 'landed moral economy' (Neumann, 1998, p. 11) is interpreted as a perceived infringement upon traditional, long-established rights to the land. Many *galamsey*, fully aware that their operations are illegal, argue that, for them, mining is a traditional way of life that predates gold extraction by large-scale and predominantly foreign operators. Others claim endorsement by local chiefs to work on concession land (Hilson and Yakovleva, 2006). As in several other developing countries with small-scale, illegal mining activities, conflicts over land, often violent, are the consequence (Andrew, 2003).

Regulation of natural resource management by the state, be it in the context of forests, grazing lands, wilderness areas, or, in this case, precious minerals, often occurs in the form of 'criminalization' (Peluso, 1992; Neumann, 1998; Kull, 2002). Criminalization, as defined by Kull (2002, p. 928), is a 'negative redefinition of a resource management practice [...] in order to assert specific claims to resources'. Resistance is understood as 'an attempt – through actions and words – to forestall or fight criminalization, to protect one's rights and impede interference, in order to assert alternative claims' (Kull, 2002, p. 928). Criminalization (or domination in a wider sense) and resistance are a dialectical pair that reflect exercises of power (Kull, 2002, p. 929).

In Ghana, land use conflicts and environmental contamination serve as justification for criminalization through rhetoric and fundamental human rights assaults. Infringing on concession land turns marginal miners into political criminals. In its most extreme form, criminalization turns into repression. Some companies have a non-recognition policy with *galamsey* miners. Evictions are not uncommon. At the local level, District Assembly members and chief executives have tended to support companies in cracking

down on *galamsey*; in response, some groups of illegal miners are now armed (Carson et al., 2005). The most contentious and violent conflicts are reported from the concession of Bogoso Gold Limited (Hilson and Yakovleva, 2006), now Golden Star Resources, with up to 20,000 illegally operating miners. In November 2006, the government conducted a country-wide operation named 'Flush Out' during which hundreds of *galamsey* were removed from concession land and their equipment was confiscated or destroyed (Codjoe, personal communication).

In the dominant discourse, the *galamsey* are also perceived as environmental criminals. To justify the recent forceful removal of illegal miners from concession land, *galamsey* were accused for deficient rules and regulations, irresponsible use of mercury, and lack of accountability for environmental degradation (Ghana Web, 2006). At the same time, many non-miners in mining towns blame *galamsey* for recklessly polluting drinking water and other natural resources due to the widespread use of mercury in the gold amalgamation process. Yet, for the *galamsey*, mercury amalgamation is not only simple and relatively inexpensive, but is also the only currently available means of extracting gold.

Despite marginalization and criminalization, states are rarely monolithic entities where domination and repression occur ubiquitously. As argued by Kull (2002), there is frequently room for opposition, negotiation, and arrangements, even bribes. Some administrators show their human side, understand and adapt to local contexts, and speak for moderation and collaboration. For example, a police executive we spoke with in one of the major mining towns said:

'If you enforce rules and regulations strictly, people will hate you. There are no jobs out there, so what else could they [the *galamsey*] do? It is the responsibility of the government to find employment for our youth.'

One of the MC district officers shared his frustration about the institutional directives to serve only registered miners when those without a license outweigh the former by 5:1. A narrow focus on legal operators with respect to mercury-awareness raising is counter-productive, said the officer. Yet, engaging *galamsey* has become increasingly difficult as MC officials are perceived as police rather than representatives of a support structure.

Despite recently emerging efforts to promote public-private partnerships, stakeholder capacity building, and community collaboration (Carson et al., 2005), the majority of state officials, environmental bureaucrats, and representatives of civil society are slow in recognizing the legitimate role of ASM as a livelihood. This persistent lack of willingness to reconsider the dominant narrative not only reveals an embedded discrimination against the predominantly poverty-driven ASM sector but further perpetuates poor social and environmental conditions from which ASM communities attempt to escape.

More specifically, it exacerbates the mercury problem. The government essentially condemns small-scale miners for mercury pollution without providing them with technically and socio-culturally appropriate education on environmental and health impacts and offering adequate solutions. Unlike most cases of environmental injustice (e.g., Agyeman, 2005) where hazardous or toxic material is dumped on disadvantaged communities, the ASM sector creates its own contamination. The injustice lies in the fact that the criminalization of the ASM sector robs the miners of their agency to articulate and solve the environmental problem they cause and experience. Ostracizing these miners precludes any serious attempts for recognition and participation – two key notions of environmental justice (Schlosberg, 2004). It prevents them of their right to fair treatment and collective decision-making.

We argue that dismantling the anti-*galamsey* discourse ought to start with a reassessment of the mercury debate. By perpetuating the environmental narrative of reckless mercury contamination, governmental officials, consultants, and researchers alike reinforce their hegemony over, and within, these narratives, thereby undermining possibilities for self-determination among small-scale miners. The following section provides an overview of mercury use in the ASM sector, evidence (and lack thereof) of environmental and human contamination, clinical symptoms, and possible solutions from retorts to community-based risk appraisals and communication.

2.2. Mercury usage and contamination

2.2.1. Description of mercury use in gold extraction

Mercury (Hg), the only liquid metal, has been used in the mining industry to amalgamate and concentrate precious metals since the Phoenicians and Carthaginians applied it around 2700 B.C. (Eisler, 2003). Today, it is used by small-scale gold miners in more than 50 developing countries (Veiga et al., 2006). In Ghana, the mercury law from 1933 banned Hg in gold mining, although the practice continued and the government legalized it for the ASM sector in 1989, triggering a sharp increase in consumption (Donkor et al., 2006a). While cyanide replaced mercury

in gold extraction processes in most large-scale operations after 1933, the *galamsey* started to rely on mercury only about 30 years ago when gold extraction became more difficult (Rambaud et al., 2000). Between 1994 and 1999, roughly 25,000 kg of mercury were imported to Ghana, mostly from Europe and Canada, 97% of which was destined for the ASM sector (Amegbey and Eshun, 2003).

In Ghana, panning with Hg is the predominant method for the recovery of gold from both alluvial and hard rock mining sites (Amegbey and Eshun, 2003). The latter involves the digging of shafts with picks, shovels, hammers, and chisels or blasting with dynamite, to be followed by the crushing and grinding of ore rocks with mechanized metal mortars and pestles. The amalgamation process is identical under both methods. First, the gold-containing material is washed on sluices where the heavier gold particles are caught and concentrated on carpets or towels due to gravity. The concentrate from the sluice box is re-assembled in rubber dishes or wooden pans. Through panning, the undesirable sediments are separated from the gold particles until the latter clearly appear in the final concentrate.

Next, a carefully gauged quantity of mercury is poured into the miner's palm and added to the concentrate in the pan. Mercury is usually mixed by hand with the concentrate, forming a lump or ball of mercury–gold amalgam. Water is added several times to discard tailings and remove lighter particles until only the amalgam remains. The amalgam is then squeezed into a piece of cloth to recover excess mercury (often re-bottled and used again). Some miners put the fabric with the amalgam into their mouth to suck out additional mercury. Finally, the amalgam is placed into a small can on a stove or coal pot to roast for 15–40 min, depending on size. Burning can also occur with a blowtorch. Mercury losses occur at various stages during gold production: (1) during amalgamation, where mercury may be washed out during the gravity washing; and (2) during burning, where mercury, with its high volatility, is released into the atmosphere. After burning, a sponge-like gold *doré* stays behind in the can. When the gold has cooled, it is weighed and ultimately sold. Fig. 1 illustrates the various steps of the process. Due to impurities and trapped mercury, the gold often undergoes a refining process off site

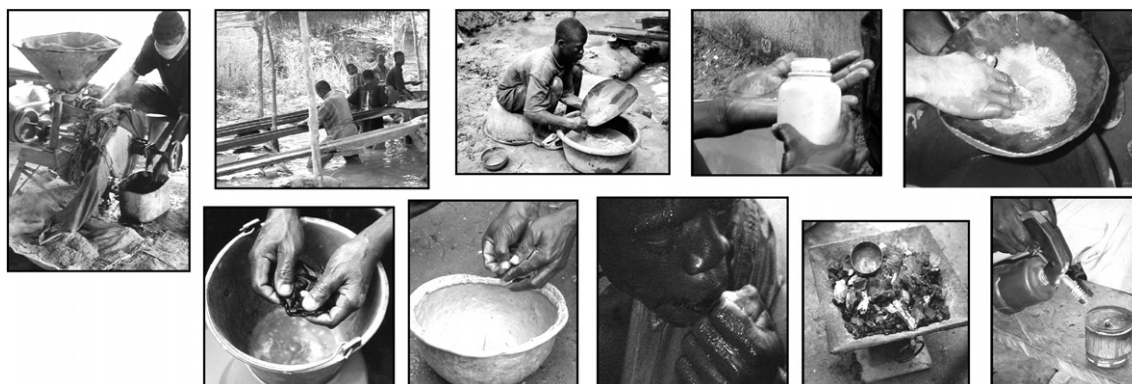


Fig. 1. Process of gold extraction process from grinding to washing, amalgamation, and burning.

that involves additional heating steps and the use of acid, borax, and soda ash. It is estimated that one or two grams of Hg is lost for every gram of gold produced in ASM (Veiga and Baker, 2004).

In Ghana, mercury is officially sold through licensed mercury dealers, as prescribed by the 1989 Mercury Law. One vial, locally known as '*poho*' (similar to an eye drop bottle), contains approximately 52.2 g of mercury. In the summer of 2006, one *poho* was sold in the major ASM centers in the Southwest for 80,000 Cedi (Amankwah, personal communication; Hilson and Pardie, 2006). While the Mercury Law stipulates good mining practices in the use of mercury, it does not include any guidelines in terms of handling and disposing of the chemical, which makes compliance and monitoring difficult (Amegbey and Eshun, 2003). According to a survey by the same authors, mercury in ASM is most often stored on the site (70%), nearly always handled without gloves (91%), and typically heated in open air (98%).

2.2.2. Clinical symptoms of mercury intoxication from small-scale mining

Through the ASM amalgamation process, miners release mercury in two forms: metallic mercury and mercury vapor. Metallic, elemental mercury (Hg^0) is discharged into the environment through tailings and released during burning; mercury vapor is both inhaled and deposited back onto the soils. Elemental mercury can be oxidized into soluble inorganic Hg^{2+} , which can be transformed by naturally existing bacteria into toxic organic forms, such as methylmercury (CH_3Hg) (Beijer and Jernelov, 1979), a known neurotoxin. The CH_3Hg increases in concentration, or is biomagnified, up the aquatic food chain and can result in deleterious effects on biota and ecosystem functions (Hinton and Beinhoff, 2005; Donkor et al., 2006b). CH_3Hg -contaminated fish and other food represent critical health risks to people.

Numerous health problems can result from exposure to Hg vapor. Hinton et al. (2003) list the following, with increasing exposure: kidney pain, respiratory problems, dizziness, gingivitis, and muscular tremors; psycho-pathological symptoms such as depression and exaggerated emotional responses, which can be mistaken for alcoholism, fever, or malaria; dysfunction of kidneys, vomiting, and potentially death. Although anecdotal evidence of mercury contamination exists from various sites around the world, only a limited number of studies actually detected clinical evidence of mercury poisoning (Porcella et al., 1997; Eisler, 2003). In Ghana, no official records exist of small-scale miners having died through mercury intoxication (Adimado and Baah, 2002). Due to a lack of medical records and purposeful monitoring of exposed miners, moderate to severe mercury intoxication can be presumed, but not substantiated.

While occupational hazards associated with the handling and inhalation of mercury are of serious concern, especially as most miners do not wear protective gloves or masks, consumption of CH_3Hg -contaminated food

and water are even more worrisome because the mode of contamination is indirect and less visible. Health problems associated with CH_3Hg include, with increasing exposure: visual constriction, numbness of extremities, impaired hearing, speech and gait; muscular atrophy, seizures and mental disturbance; spontaneous abortion and sterility (Hinton et al., 2003).

2.2.3. Impact-based assessments of mercury contamination

Given the serious health risks associated with mercury contamination, numerous studies have been undertaken to quantify mercury levels in the environment (water, soils, sediments, fish, and crops) and in human blood, urine, hair, and nails. Unlike cyanide that can degrade within a couple of hours on exposure to light and oxygen (Amankwah, personal communication), mercury contamination can be detected many years after a spill.

Many of the existing studies reflect the narrative of reckless *galamsey* Hg pollution and contamination even though the results are mixed and the culprits unclear. Donkor et al. (2006a, p. 2–3) report the 'use of enormous amount of metallic mercury' in ASM, the discharging of mercury to the environment being done in an 'abusive manner', and 'mass extinction of some biological species' in the main river systems of the Ghanaian gold belt, including the Offin, Pra, and Ankobra Rivers. At the same time, they state that 'even though Hg levels in water, soil, and sediments [in the Pra River] were below WHO [World Health Organization] safe guideline values, the current state of affairs poses a serious environmental threat' (2006a, p. 2). Elsewhere, the authors report mercury levels below the WHO safe drinking water standard of $1 \mu\text{g L}^{-1}$, no marked differences in Hg in soil between mining and non-mining sites, and rather low levels of Hg in the top 0–10 cm sediment layer, although unsafe levels of mercury in carnivorous fish (Donkor et al., 2006b).

A 2000 UNIDO study (Babut et al., 2001) from the Dumasi area (Bogoso-Prestea road) showed no ground or surface water above the WHO recommended mercury limit, low concentrations in most vegetables, but high values in sediments ($>0.18 \mu\text{g g}^{-1}$) and most fish samples ($0.5 \mu\text{g g}^{-1}$). Other studies (Golow and Adzei, 2002; Golow and Mingle, 2003) report high levels of mercury in soils and cassava leaves around Dunkwa-on-Offin, however from a time when Dunkwa Continental Goldfields, the only mercury-using large-scale dredge mining company, was still operational⁵. Bannerman et al. (2003) describe Hg concentrations in surface water in Western Ghana generally below the WHO standards, excepting one sample ($21 \mu\text{g L}^{-1}$). A study by Kuma (2004) shows high levels of mercury ($80\text{--}97 \mu\text{g L}^{-1}$) in surface water and spoil heap water samples in Tarkwa.

Existing studies on mercury in human tissue also reveal mixed results. The UNIDO assessment in the mining town

⁵ Dunkwa Continental Goldfields collapsed in 1999.

of Dumasi showed Hg levels in both urine and hair below safe levels⁶ (mean values of $23.8 \mu\text{g L}^{-1}$ and $3.85 \mu\text{g g}^{-1}$, respectively) while mercury in blood exceeded the recommended maximum level (mean $24.4 \mu\text{g L}^{-1}$) (Rimbaud et al., 2000). High concentrations were associated with high consumption of mercury-contaminated fish. Adimado and Baah (2002) report elevated Hg levels in blood and hair among Ghanaian children, also as a result of heavy consumption of contaminated fish. Amegbey and Eshun (2003) report $0.1\text{--}0.8 \text{ mg m}^{-3}$ of mercury concentration in the air of gold buyers' refinement shops. Finally, Donkor et al. (2006b) conclude that samples along the main rivers in the southwestern gold belt show mercury concentration in human hair within safe levels, although the results varied according to seasons and the extent of fish consumption.

2.2.4. Solutions: retorts and community-based risk appraisals and communication

The government has supported the use of retorts to tackle the mercury pollution problem. Retorts are small containers in which the gold–mercury amalgam is placed and heated. The volatile mercury travels through a tube and condenses in an adjacent, cooler chamber (Hinton et al., 2003). The model that is currently promoted and distributed to registered miners through the MC Small-Scale Mining District Offices is the ThermEx[®] retort, commissioned by UNIDO (Hilson and Pardie, 2006; Hilson, 2006). It is made out of glass and transparent, which allows miners to closely observe the condensation process (Veiga and Baker, 2004). While this retort therefore constitutes an improvement over earlier models, costs are high (500,000 Cedi⁷ for one subsidized retort), the holding capacity is low ($<30 \text{ g}$ of amalgam), and the device is easily breakable (Hilson and Pardie, 2006; Hilson, 2006). Moreover, as explained by one MC district officer, the separation of gold and mercury inside the retort takes at least twice as long as on a stove; if a miner walks away during the process, somebody may steal his gold. If only one retort exists per site, no simultaneous burning can occur. Most problematically, the commissioned agents are allowed to promote and sell the retort to licensed operators only, leaving out the 85% of all small-scale miners that are most in need of healthier and cleaner technologies. Alternative retorts such as those proposed by Hinton et al. (2003b) and Crispin (2003), many designed with local materials

(e.g., scrap tin), or alternative devices that do not use mercury⁸ are not available in Ghana.

Despite over a decade of donor efforts to increase environmental awareness in mining communities, risk communication campaigns have grossly ignored the socio-economic and cultural dynamics and educational needs of ASM populations and, hence, have been largely ineffective (Hilson, 2006). The only risk communication material that the authors encountered at the MC Small-Scale Mining District Offices were brochures of the ThermEx retort, with pictures of Asian mercury-intoxicated patients to whom Africans may or may not relate, and a portable video with dramatized footage of cases of contamination. Although registered miners are the official target audience for the educative video, a participant from one of the MC SSM Offices affirmed that he showed it to entire communities as mercury was affecting everybody. This reflects the recommendations by Hilson and Pardie (2006) to not discriminate between legal and illegal miners when it comes to mercury risk communication.

Given the failure of the state, international donor organizations, technical agencies, and consultants alike to educate miners and solve the mercury problem in a cost-effective way, an integrated approach is needed that provides space and support for active community participation. It is not viable to promote safer and healthier mining practices if the target population is uninformed and profiled as criminals (Heemskerk, 2004). What is needed is not another effects-based study, but an approach that allows us to tackle the mercury problem as entwined with the multiple environmental, socio-economic, and health-related challenges in ASM communities. There is currently no alternative to mercury amalgamation in Ghana. Urging miners to reduce mercury-related impacts on the basis of ambiguous lab results that they have no access to is futile, if not counter-productive. This is particularly true when these impacts appear minor compared to other risks in the sector and when immediate livelihood needs are more critical than potential long-term health risks (Spiegel and Veiga, 2005). We must elicit information from miners and other community members, both men and women, to better understand their knowledge base and needs, and bring information to them, as suggested by Heemskerk (2004) and Spiegel et al. (2006). The following sections are an attempt to contribute to this emerging integrative and community-based approach.

3. Study area and research methodology

3.1. Description of the research sites

This pilot study was conducted in August 2006 and involved a research team of six people, including one geographer, one hydrogeologist, and four masters students from the Regional Institute for Population Studies (RIPS)

⁶ WHO levels for mercury in urine: $50 \mu\text{g L}^{-1}$ = maximum acceptable concentration; $100 \mu\text{g L}^{-1}$ = minimum concentration before developing symptoms of mercury poisoning (Eisler, 2003). Mercury in hair: safe level of mercury concentration (in the form of methylmercury) = $4\text{--}7 \text{ mg kg}^{-1}$; $10\text{--}20 \text{ mg kg}^{-1}$ = associated with abnormal infant development; $50\text{--}100 \text{ mg kg}^{-1}$ associated with paraesthesia (De Lacerda and Salomons, 1998; Eisler, 2003). Mercury in blood: recommended maximum level = $10 \mu\text{g L}^{-1}$ (Eisler, 2003). Inhalation of metallic mercury vapor: recommended exposure level of $50 \mu\text{g m}^{-3}$ at workplaces and gold dealer shops (Eisler, 2003).

⁷ In August 2006, 500,000 Cedi were worth \$56 (exchange rate \$1 = 9424 Cedi).

⁸ Examples for technologies that do not use mercury are gravity separation, improved sluicing, Gemini tables, and aluminum sluice boxes with polymeric magnetic sheets (Vieira, 2004, 2006).

at the University of Ghana. Two *galamsey* sites were selected with the help of officials from Small-Scale Mining District Offices who were familiar with local artisanal operations. Both sites are situated in the Kumasi Basin in the southwestern part of the country. The basin is largely composed of sedimentary and meta-sedimentary rocks, including sandstones, quartzites, conglomerates, and phyllites (Kuma, 2004). Gold is found in the Early Proterozoic Birimian greenstones, which are associated with various metal sulfides (Hammond and Tabata, 1997).

The first site (here referred to as Site #1) is a deep alluvial site along the Offin River and next to Dunkwa-on-Offin (population of 45,000) in the Upper Denkyira District, Central Region. Officially, this site is located on the concession of Dunkwa Continental Goldfields, a corporation that has not been operational for more than 5 years. While the corporation's future is unknown, no other party can legally acquire a license for this area and local miners are essentially forced into illegal operations. According to an estimate by the Dunkwa police, more than 2000 *galamsey* mine along the river to both sides of the town. The other study site (Site #2) is a hard rock area next to Bogoso (population of 16,500) in the Wassa West District, Western Region. The site there is located on the 85 km-long concession of Bogoso Gold Limited (now Golden Star Resources). The corporation is actively exploiting and exploring its land and, therefore, has become repeatedly in conflict with infringing *galamsey* (Fig. 2).

The number of miners fluctuates between 50 and 200 on Site #1 and between 30 and 500 on Site #2, mainly depending on the availability and functioning of equipment such as excavators and water pumps. The socio-economic characteristics of the miners in the research sample (Table 2) reveal a broad spectrum of backgrounds. Ages ranged from 15 to 42 years for women and 16 to 46 years for men. Among the men in the sample, time in mining varied from 0.5 to 23 years while for women the range was 0.1–5 years. The majority of interviewed *galamsey* came from the area and are 'sons and daughters of the community' (F. Momade, personal communication). While men view artisanal gold-mining as a longer-term employment, women tend to join *galamsey* camps on a temporary basis for short-term income generation.

3.2. Description of research methods and analysis

The mixed methods used in this study were highly participatory and integrative. We drew upon the ecosystem approach to human health ('ecohealth'), for ASM communities (Lebel, 2003; Spiegel and Veiga, 2005). It focuses on the links between humans and their social and biophysical environments and is based on transdisciplinarity, participation, and equity (Lebel, 2003). We started with informal interviews with seven group ('gang') leaders at the *galamsey* sites to gain a basic understanding of the use of mercury, gloves, retorts, spillage, health effects, and access to information about mercury and alternative technologies. We

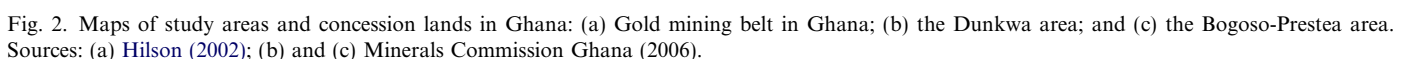
then used risk ranking and scoring, conceptual and hazard mapping, chemical indicator strips, and surface and ground water sampling, as explained below. During mining work hours, participants were chosen with the help of gang leaders. Most of the research activities took place after the mining work and involved all those who volunteered to be part of the study.

Participatory risk ranking and scoring was used to elicit problems and risks men and women miners had been encountering on the sites. We wanted to understand how pivotal mercury-related contamination was compared to other livelihood hazards. We used the terms risks, problems, and hazards interchangeably. A total of 16 women and 30 men took part in this assessment. Among the men, we divided participants into a younger (18–25 years) and an older (>25 years) age group to capture short and long-term experiences within the sector, amounting to 17 and 13 participants, respectively. As there were only few women at the sites, with roughly the same time spent in mining, no age differentiation was made. Participants were asked to free-list problems they had experienced at their sites and depict them on blank index cards. Next, they ranked these problems by order of importance, the most troublesome on top. Participants were asked to use pebbles to indicate the severity of each stressor, ranging from 1 (barely noticeable) to 5 (life threatening). Finally, they described strategies to reduce or solve each problem and their rate of success.

To analyze the responses from the ranking and scoring activity, we followed Quinn et al. (2003) and Tschakert (2007). For each risk mentioned, an incidence index (I) was calculated. This index, ranging from 0 to 1, is a simple measure of the proportion of participants identifying each particular problem. An importance index (P) was calculated based on the order in which risks were ranked by each group. This index also ranges from 0 to 1, and is defined as $P_j = [(r - 1)/(n - 1)] \times (-1) + 1$ where r is the rank and n is the total number of risks identified by that participant group. The mean value for P_j was then calculated for the subset of groups who identified the particular problem. As a last step, a severity index (S) was calculated based on the number of pebbles participant groups assigned to each risk. This final index represents the total number of pebbles for each risk per number of participant groups mentioning this particular problem and ranges from 1 to 5.

Next, we used conceptual mapping (also known as mental models) to understand how miners and medical personnel in Dunkwa and Bogoso think about mercury contamination. Mental models are psychological representations of real or hypothesized situations, generally in the form of individual conceptual maps of ideas (Bostrom et al., 1994; Morgan et al., 2002). Six *galamsey*, three doctors, two nurses, and one health volunteer participated in this activity. First, participants were asked to brainstorm causes of mercury contamination, list these on blank index cards, and connect the cards with arrows to the 'problem',

potential differences in 'social constructs' of mercury pollution between 'expert' (medical personnel) and 'non-expert' (miners) participants and to identify knowledge gaps and information needs. The results from the individual



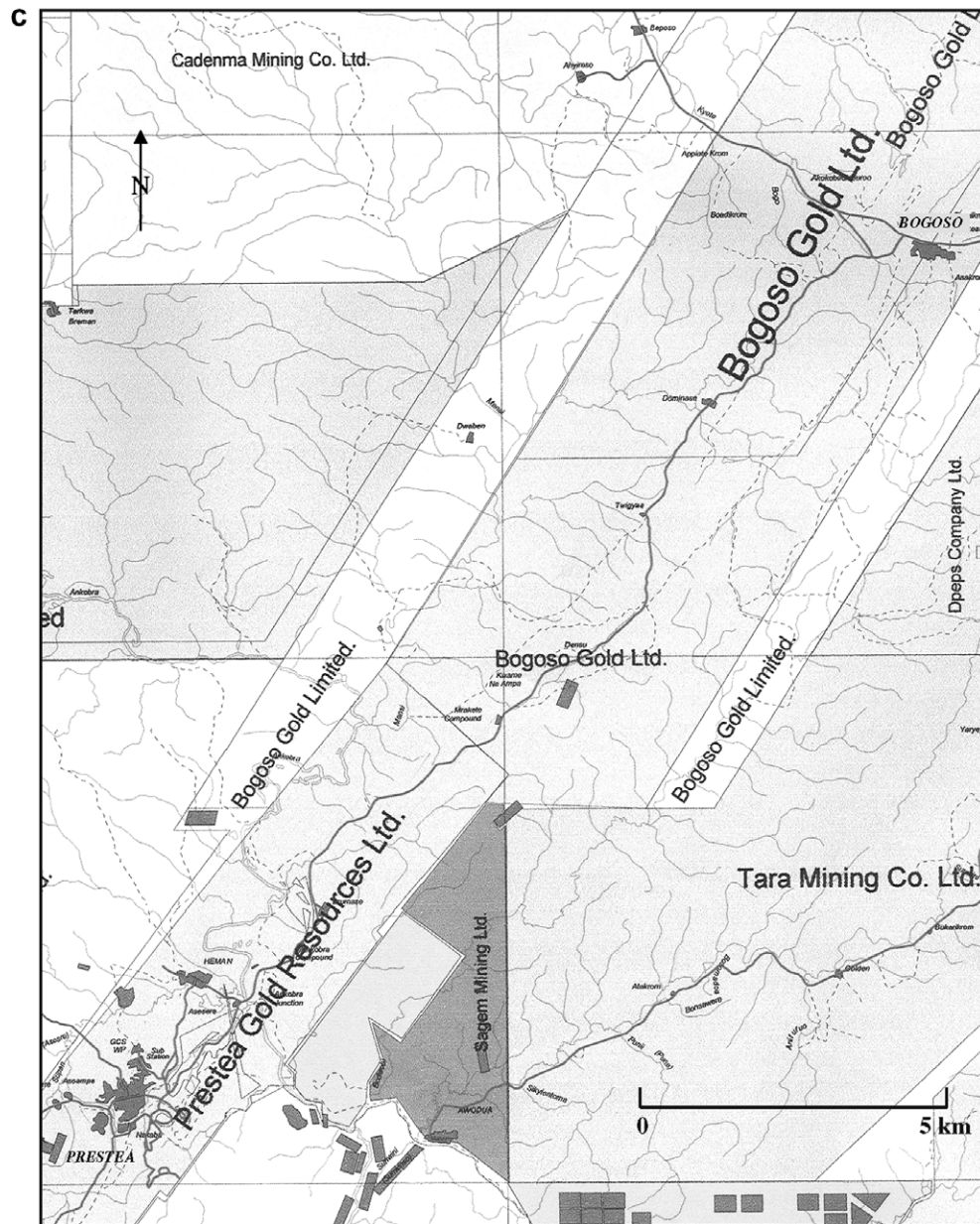


Fig. 2 (continued)

Table 2
Socio-demographic characteristics of miners in the study sample

Variable	Men	Women
<i>N</i>	47	18
Age (SD)	28.3 (9.6)	26.1 (7.8)
Single (%)	77	50
Married (%)	20	44
Other (%)	3	6
No education (%)	6	22
Primary education (%)	17	38
JSS/middle school (%)	66	39
Secondary/vocational/technical education (%)	11	0
Years in mining (SD)	7.1 (6.2)	1.2 (1.3)
Years at current mining site (SD)	3.1 (6.8)	0.3 (0.4)

concepts were aggregated into a final composite conceptual map.

On Site #1, where mercury is used daily to extract gold, we relied on mercury indicator strips to test contamination in surface water and discuss potential health impacts of Hg use in collaboration with 50 miners.⁹ We asked the participants to identify, on a locally drawn map, all safe and contaminated water bodies and other spots on their site. Then, the indicator strips were explained and 15 men volunteered to participate in a ‘competition’ and sampled the spots they considered most contaminated. The strip results were

⁹ At Site #2, ore containing rocks are transported to a processing site in Bogoso where mercury is used during the panning process. The burning occurs either at the processing site or in refining shops in town. Hence, indicator strips were not used at this second site.

compared and the participant with the highest contamination strip was declared the ‘winner’.

Indicator strips are colorimetric methods designed to detect the presence of various materials in water samples. We used SenSafe mercury kits; in the presence of inorganic Hg^{2+} , these strips produce a purple tint. After 2 min, the color of the circle on the strip is visually compared to the given reference scale, ranging from 0 to $1000 \mu\text{g L}^{-1} \text{Hg}$. While the results of the mercury test strips are impacted by the presence of other heavy metals, they provide qualitative information, and, more importantly, immediate results in the field that are accessible to all participants. Research on commercial indicator test kits for arsenic suggest that they provide a reasonable estimate of the presence or absence of contamination (e.g., Kinniburgh and Kosmus, 2002; van Geen et al., 2004, 2005). No accuracy analyses were found on commercial mercury test strips, albeit improved indicator strips may be available (Shi and Jiang, 2002).

Finally, we collected water samples for lab analysis¹⁰ at both sites to quantitatively estimate water quality in surface and groundwater bodies. We tested for total mercury, total arsenic (a known natural contaminant in the area), and basic anions and cations (indicators of water provenance). The samples come from four boreholes near Site #1 and three boreholes in towns adjacent to Site #2. The boreholes were equipped with human-powered pumps and nearly continuously in use, which reduces concerns of sampling water within the standpipe. Two surface water sites were also sampled, including the Offin River, which miners at Site #1 use as a source of drinking water despite proximity to their amalgamation activities.

4. Community understanding of mercury and other hazards

4.1. Results from risk ranking

The participatory risk ranking and scoring revealed a total of 25 risks and hazards that men and women miners

face on a regular basis. The most common ones are depicted in Figs. 3 and 4. Clearly, the most serious hazard on both sites is collapsing sediments, pits, or shafts, with a severity of 5 (‘can kill’) and mentioned by women, younger men, and older men. The other life-threatening risks, except for fighting among gang members, were all on the hard rock site; slipping and falling into pits was mentioned by all three groups. Women usually carry basins full of sediments on their heads while hastening from the excavation site to the area where rocks are crushed and washed. As shafts are largely open holes in the ground with minimal protection around them, the risk of falling into any of them is high. Accidents happen frequently, and some are deadly.

Additional life-threatening risks were those related to dynamite rock blasting and underground heat. The latter refers to high temperature and reduced oxygen in shafts (up to 45 feet in depth). Other risks, albeit rarely fatal, were eye problems resulting from muddy water on the alluvial site and rock particles and smoke from crushing and grinding at the hard rock site. None of the miners had protective eye wear. All miners, including women, complained about waist pain due to the continuous shoveling, lifting, and carrying of sediments. In addition, all groups of miners on the alluvial site reported risks of guinea worm infections as a result of standing in water-filled excavation pits all day

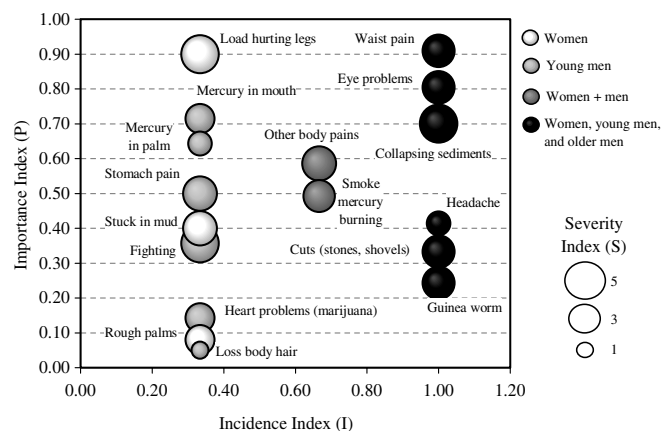


Fig. 3. Mining-related risks, Site #1 (deep alluvial mining site).

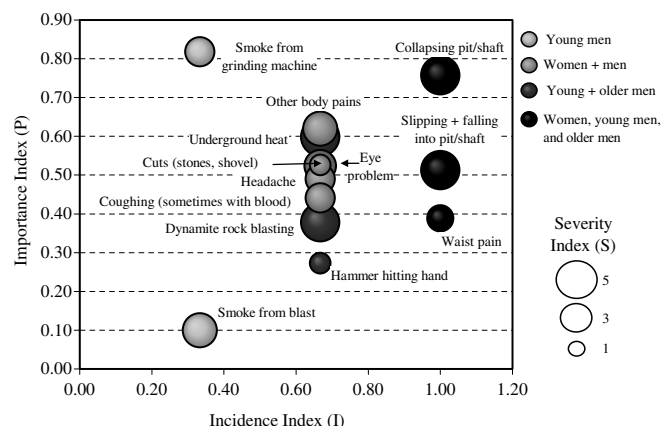


Fig. 4. Mining-related risks, Site #2 (hard rock mining site).

¹⁰ Sampling procedures followed the U.S. Geological Survey National Water-Quality Assessment Program (NAWQA) protocol as best as possible (Koterba et al., 1995). The sampling locations were georeferenced using GPS. Conductivity, temperature, and pH were collected in the field. The analysis of cations Na^+ , K^+ , Mg^{2+} , Ca^{2+} , Fe^{2+} , and NH_4^+ and anions Cl^- , SO_4^{2-} , HCO_3^- , CO_3^{2-} , and NO_3^- were measured by ion chromatograph in the Ecological Laboratory at the University of Ghana. Steps for total mercury and arsenic sampling were filtered with a $0.1 \mu\text{m}$ syringe filter in the field and collected in acid-washed HDPE bottles. Approximately four drops of concentrated, trace metal grade HCl added in the field per 30 mL of water so that the pH of the sample registered less than 2.0. All samples were immediately double-bagged, and kept as cool as possible after collection. Total arsenic and total mercury were measured by Graphite Furnace Atomic Absorption Spectrometry at the Ecological Laboratory. Trip blanks were used to assess contamination introduced from the sample container and during sample transport. A trip blank is analyte-free water collected in the appropriate sample container with the proper preservative, which is taken into the field and returned to the laboratory without being opened. Trip blanks showed no concentration of any of the tested materials except NO_3^- .

long. Other issues include fractures, crushing injuries, respiratory tract infections, and death from collapsing pits, as reported for *galamsey* from a regional hospital (*Ghanaian Chronicle*, 2005).

Risks related to mercury contamination were explicitly addressed on Site #1 only. This is not surprising as amalgamation and burning occur directly on the site, even though in a restricted area. Mercury in one's palm, one's mouth, and smoke from mercury burning were raised as concerns by women and young men while older men, most of whom had been on the site for several months and years, felt the problem was manageable. In fact, responses from the informal interviews suggest that much care is taken when handling mercury. A group leader explained:

'Mercury is expensive, so we make sure we don't spill it. If it happens, we collect the mercury droplets with a spoon or a shovel. Only gang leaders are allowed to use mercury. We collect excess mercury on this mound of sand so we can use it again later.'

This is in stark contrast to a recent news article that reports 'large pools of mercury lying untended' at a site along the Bogoso-Prestea road (*Ghanaian Chronicle*, 2005). The leaders agreed, however, that mercury contact with a person's mouth should be avoided. In Bogoso, amalgamation and burning occur at grinding and washing locations and

gold buyers' shops. Hence, mercury did not feature in the miners' risk assessment at Site #2.

Overall, the results suggest that men and women artisanal miners face more immediate life-threatening risks than mercury intoxication on their sites. Several of these risks can result in death. Although protective measurements are taken, such as using props for shafts and reducing the distance between pits to avoid collapsing sediments, the environment remains highly risk-prone. First aid is rarely provided on sites. Gloves, helmets, goggles, and boots – the elemental safety wear – are essentially non-existent. While they were deemed efficient, only very few miners were able to afford them.

4.2. Results from conceptual mapping

This section presents the findings from the mental models on mercury contamination. These models provide details on how miners and medical personnel understand the drivers and consequences of contamination and its spatial scales that go beyond the immediate working areas (*Fig. 5*). It is worth noting that all miners interviewed had heard about the negative human and environmental impacts of mercury, either on the radio, through MC officers, the Small-Scale Mining Association, or from other miners.

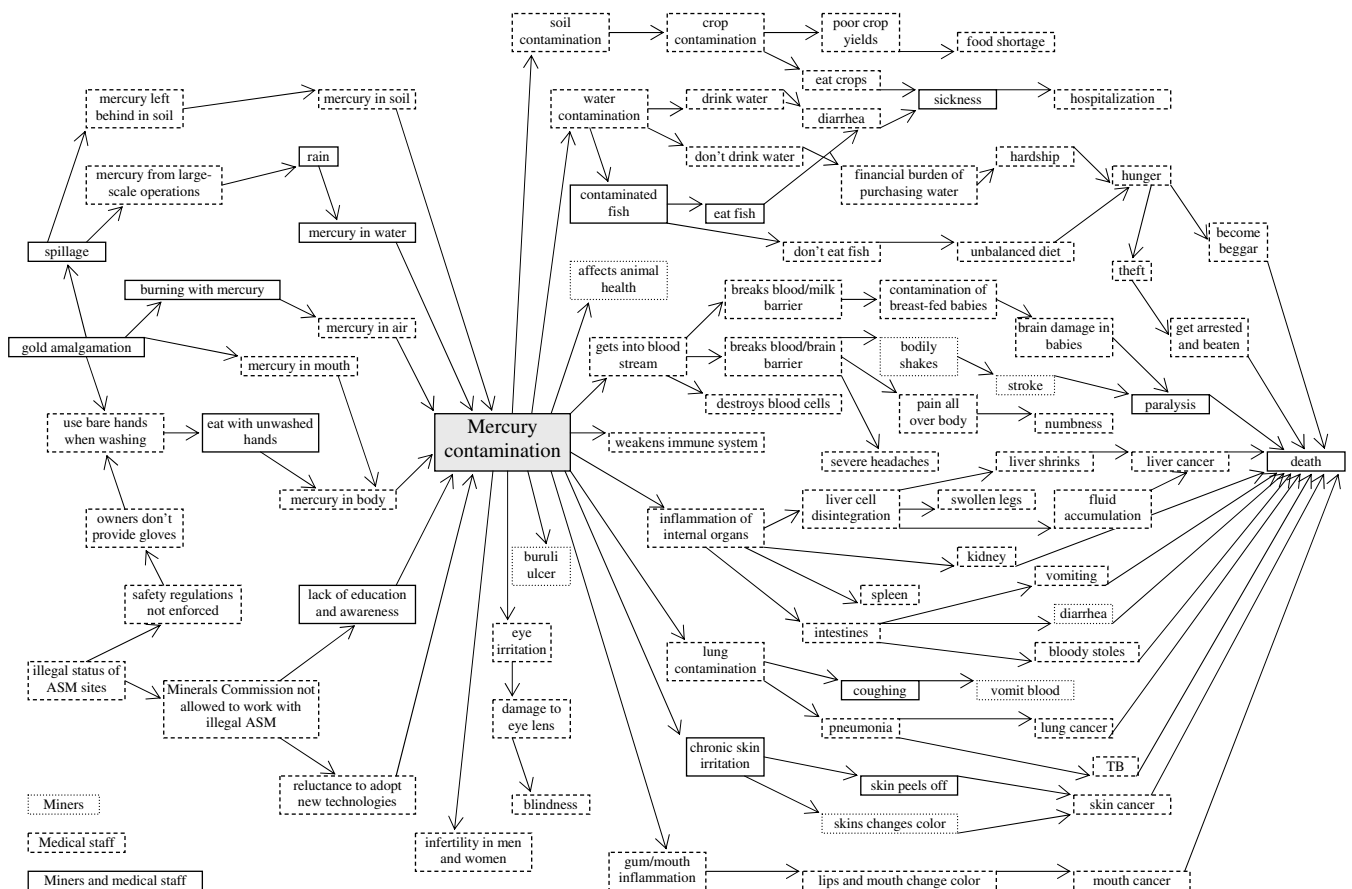


Fig. 5. Aggregate mental model of mercury contamination (combined miners and health personnel).

As for the causes of mercury contamination, miners agreed that the three main channels were through the burning of mercury after amalgamation, dispersal of mercury in water bodies after spillage and rain, and contact with the mouth through unwashed hands after amalgamation. Lack of education and awareness aggravate contamination. The health personnel reinforced these points while adding other, more complex issues such as previous mercury pollution from large-scale operations and sorption on soils. More importantly, two doctors argued that the illegal status of the miners undermined awareness raising through the MC and prevented safety regulations from being enforced.

The mining participants raised many different consequences of Hg use: skin irritation, respiratory problems, muscular tremors, numbness of extremities and atrophy, vomiting, gastro-intestinal problems, and finally death were all part of their mental models. As for effects on the environment, there was consensus that mercury can affect animals through contaminated water and enter the food chain, contaminate fish, and cause sickness among humans. The concepts elicited by the interviewed health personnel were exhaustive, including more details than those understood by the miners, especially with respect to neurological symptoms, including those in pregnant women and babies, inflammation of internal organs, eye irritations, and various types of cancer. The carcinogenicity of Hg through mining exposure, though, is debated (IARC, 1993). As stressed by one doctor, mercury has not been observed as an immediate poison but rather a trigger for gradual processes that may take 10–15 years. However, not all the symptoms listed here are necessarily associated with mercury contamination when diagnosed at the hospital. As one professional nurse explained after some joint fieldwork:

‘I had a patient from one of the mining communities who was suffering from acute psychosis. The disease was managed but one could not relate the psychosis of the young man to this unguided job. And so, no follow up was done and the community was not educated on how to minimize or avoid job related hazards by ensuring simple and affordable safety measures at work.’

On the environmental side, two doctors cited crop contamination through polluted soil resulting in sickness and potentially death. One female health volunteer elaborated on the complex socio-economic and health ramifications of mercury contamination for people’s livelihoods that clearly go beyond the narrow clinical analysis:

‘To avoid polluted drinking water and fish, people would need to purchase water or stop eating fish; both lead to hardship and hunger. People would become beggars or steal, some may get arrested or even die.’

These findings suggest two important axes for science and community collaboration. First, common concepts and overlaps in knowledge ought to be used as starting points for in-depth awareness raising. The medical personnel have

a good understanding of human and environmental health risks associated with mercury contamination. What is lacking is an effective channel to make this information accessible to mining communities. Although one doctor had once been invited by the Small-Scale Mining Association to educate miners about mercury, he deplored the lack of funds for more and more effective outreach. Second, linking toxicity of mercury, independent of its source, to livelihood risks in adjacent communities seems most tangible through an explicit emphasis on potentially contaminated fish and crops. As shown, concentration of mercury in fish, vegetables, and vegetable leaves, particularly cassava, tends to be high. This requires an active participation of women. Yet, women have so far been largely excluded from existing mercury-awareness programs. Finally, none of the miners interviewed had ever seen a retort, except for one leader.

4.3. Results from indicator strips and water samples

The indicator strips provided a tool to discuss water contamination with the miners which would not have been possible by taking water samples for the laboratory alone. We found the miners to be highly interested in conducting real-time water sampling and seeing the results, given their concern about the impacts of mercury on both the environment and human health. The strips from the alluvial site showed higher mercury values than bottled water, which was used for comparison. The strips indicated values on the order of 50–100 $\mu\text{g L}^{-1}$. Given the lab results which show ng L^{-1} concentrations of Hg, the strips likely registered the impact of iron concentrations (as high as 3.3 mg L^{-1}). Here, indicator strips were a poor representation of mercury onsite (no demarcations between 0 and 50 $\mu\text{g L}^{-1}$). Potentially better quality mercury trips should be developed and tested in this environment, particularly for educational purposes.

The lab sampling showed total Hg concentrations in surface water ranging from 0 to 67 ng L^{-1} and borehole samples as high as 286 ng L^{-1} – below the WHO standard of 1 $\mu\text{g L}^{-1}$ (1000 ng L^{-1}). These data match average Hg concentrations around Dumasí of 165 ng L^{-1} and 280 ng L^{-1} in ground and surface water, respectively (Babut et al., 2001) and mean surface water concentrations of 144–205 ng L^{-1} in the Lower Pra and Offin River Basins (Donkor et al., 2006a). The presence of metal-sorbing iron and metal-complexing organic matter may keep aqueous mercury concentrations low. Other research in this area has indicated the presence of mercury between 2 and 93 $\mu\text{g L}^{-1}$, which is in excess of the WHO limits in surface waters (Bannerman et al., 2003; Bonzongo et al., 2003; Kuma, 2004). High values are likely related to the physical system and chemical factors that control the mobilization of metals in groundwater.¹¹ We note that while we have shown

¹¹ These factors including the acidity of the system (as defined by pH), reduction–oxidation state of the aquifer, and the availability of adsorbing surfaces as defined by the geology.

low concentrations of total mercury in aqueous form, its tendency to bioaccumulate in fatty tissues still makes it a contaminant of concern, and studies assessing the concentration in sediment and fish should be continued.

5. Contaminated identities: discussion and conclusion

This study has attempted to set the stage for a counter-narrative to the dominant discourse of marginalization and criminalization of *galamsey* miners in Ghana by reassessing the mercury debate from the miners' perspective. This is a novel approach as the mercury problem has so far been presented as a technical problem that requires a technical solution, ignoring broader socio-economic, cultural, and political community issues. The *galamsey* are typically portrayed as dire environmental stewards, recklessly degrading ecosystems and endangering their own and other people's health through irresponsible use and handling of mercury. Due to their illegal status, these miners are officially excluded from governmental programs that support mercury risk communication and loans to purchase safer technologies such as retorts, as inapt as they may currently be. Also, most measurements and monitoring are undertaken without their active involvement, thus prohibiting a practical learning experience. Being trapped in this vicious cycle of lack of access to information and alternative technologies, the *galamsey* perpetuate the pollution for which they are accused and marginalized. Hence, their identities are as much contaminated by the mercury in their immediate environment as by the ostracizing rhetoric that is propagated by the media, governmental officials, and large-scale corporations.

While we do not suggest that *galamsey* miners have no part in the mercury problem, we argue that many effect-based mercury contamination studies, through their notorious avoidance of community participation, have further widened the gap between experts and potential clients. For instance, the 181 samples of blood, 120 samples of urine, 167 samples of hair, and 179 samples of nails in the 2000 UNIDO study were taken without *any* practical educational activities that could have involved miners and non-miners alike in understanding the effects of mercury as a toxic agent. The same is true for the 217 subjects, age 12–18, whose hair and blood samples were collected in the Adimado and Baah (2002) study. Donkor et al. (2006b) even admit that collecting human hair samples in mining communities along the Offin River was extremely difficult due to people's superstition. What better reason, and opportunity, could there have been to offer practical sessions and engage concerned miners in discussions about mercury and possible health effects? Sadly, the researchers preferred working with a statistically insufficient sample than seeking community participation. The same authors also found that mercury concentration in cat fish (*Synodontis sp.*), mud fish (*Hepsetus odoe*), and Kafue pike (*Clarias sp.*), all carnivorous fish, exceed the WHO's safe consumption limit of 0.5 mg kg⁻¹ (Donkor et al., 2006b). Yet, no

community follow-up was undertaken. Similarly, Golow and Adzei (2002) report 35 µg kg⁻¹ of mercury in cassava leaves close to Dunkwa, most likely due to aerial sources that go back to Continental Goldfields. The authors add that 'anybody who uses cassava leaves for preparing soup and stew . . . could be easily poisoned' (p. 235). However, no comprehensive awareness programs were put in place. More alarming still, recommendations from these various effect-based studies focus on more monitoring of groups at risk, more sampling campaigns, and the distribution of retorts, but not a single one addresses education and outreach. While we don't believe that the low concentrations of Hg found in this study implicate or exonerate *galamsey*, we found that having the miners actively participate in data collection provided a framework for discussing the environmental impacts of Hg, to which they were both receptive and inquisitive. The use of indicator strips, or similar technologies, provide an education opportunity not seen in other sampling campaigns.

Galamsey miners are certainly not oblivious to human and environmental health risks of mercury contamination. Most of them are aware of the relationship between touching, burning, and spilling mercury and clinical symptoms such as respiratory problems, muscular tremors, and skin irritations, even if they ignore the intricate ways of mercury transportation from the bottle to the human body. Yet, it simply cannot be assumed that the miners will easily accept lab results of their hair or urine samples, if they have a chance to see them, as sufficient evidence to justify the use of retorts. This is particularly true if studies are pursued without specifically targeted learning opportunities and retorts introduced by external consultants and agents from the MC who the *galamsey* meet with increasing distrust.

To date, few miners in Ghana know about retorts, other alternative technologies, or treatments for mercury intoxication. The available risk information is not tailored to the 250,000 or more small-scale miners. If they had a voice in the design, building, and testing of retorts, they may also be more likely to try and use them (Heemskerk, 2004; Hilson et al., 2007). With no alternative gold extraction technology available or affordable, forgoing the use of mercury today would imperil their immediate economic well-being and that of their dependants. Some speculate that the looming European Union ban on mercury exports¹² will radically change the situation. Prices for mercury are expected to increase and demand to decline, resulting in more efficient use and reduced releases (Hontelez et al., 2006). However, it can also be hypothesized that an official mercury ban would fuel black market transactions and further criminalize miners who rely on mercury for gold extraction.

On the theoretical front, this study illustrates so far overlooked synergies between key notions in political

¹² The EU, the world's largest mercury exporter, currently prepares a legislative instrument for a mercury export ban that is expected to be implemented between 2008 and 2011. Most affected will be developing countries (Hontelez et al., 2006).

ecology, environmental justice, and ecohealth. While political ecology is ideally suited to relate the causality of disease to politics and power (Mayer, 1996; Richmond et al., 2005), the field has essentially failed to address unequal power relations, marginalization, and injustice in the context of human-environmental health and well-being. In contrast, the environmental justice literature has increasingly argued for a need to recognize power inequalities and the plurality of injustice concepts. Plurality in this context means to include not only questions of distribution of environmental risks and injustices but also those of recognition of the diversity of participants, their differential identities and experiences as well as participation of the most affected in environmental decision-making and political processes (McDonald, 2002; Schlosberg, 2003, 2004; Walker and Eames, 2006). Lack of recognition, often expressed as disrespect, devaluation, disenfranchisement, and oppression, constrains and harms people and, most importantly, prevents them from participating, from having a 'place at the table' and speaking for themselves (Young, 1990; Fraser, 1998, 2000; Schlosberg, 2004). A 'science of environmental justice', as advocated by Wing (2005, p. 61) constitutes 'a science for the people, applied research that addresses issues of concern to communities experiencing environmental injustice, poor public health conditions, and lack of political power.' This notion of environmental justice stresses local knowledge as a complement to scientific methods of data collection (Lambert et al., 2006) and 'fair treatment', especially for those that are already marginalized and disadvantaged (Walker and Bulkeley, 2006). Schlosberg (2007) emphasizes capacity and engagement to remedy injustice and encourage human and ecological systems to flourish. Similarly, the ecosystem approach to human health (ecohealth), stresses transdisciplinarity, equity, and participation (Lebel, 2003). It calls for a holistic understanding of health by focusing on the interrelationships among the various factors that cause ill health and ecosystem degradation and those that prevent and control these risks (Forget and Lebel, 2001; Rapport and Mergler, 2004).

The importance of this study is straightforward: as long as *galamsey* are considered outlaws and used as test subjects for contamination studies, learning and changes in behavior are unlikely to occur. By integrating concepts of recognition, participation, equity, and transdisciplinarity, we argue that a political ecology of human and environmental health can provide a powerful conceptual and practical lens through which to address inequalities and injustice in the small-scale mining sector. We witnessed a genuine interest and active participation in real-time mercury measurements and health-related discussions at our two study sites. A day after the collective use of the mercury indicator strips, the owner ordered water to be trucked in for all workers to avoid drinking from the potentially polluted pond. The miners understand that inhalation of mercury vapors, consumption of contaminated fish, and direct skin contact ultimately endanger their

health and that of their families, similar to Heemskerk's (2004) findings for Suriname. Nevertheless, they face other more immediate and life-threatening risks, such as collapsing pits and shafts, waist pains, eye problems, and dynamite blasting. Any initiative that aims to reduce the comparatively invisible health impacts from Hg will be likely to fail if it does not also address broader community issues, including women at and around mining sites. Women are largely responsible for the provision of drinking water and the preparation of food at their homes. Yet, they currently do not feature in the risk communication efforts of the government or international funding agencies. Linking risks of contamination to daily livelihood decisions, such as cooking, would most certainly enhance awareness. For instance, Hinton et al. (2003a) recommend training for women to differentiate safe and unsafe fish species, quantify safe fish consumption, and test recipes to dilute fish with vegetables.

We advocate not only a more differentiated *galamsey* discourse but also more practically oriented and inclusive science and educational approaches that permit the miners to flourish. This study attempted to see the *galamsey* as research partners, not as criminals, with livelihood needs and opportunities, knowledge and knowledge gaps. The participatory research methods allowed us to move away from effect-based investigations toward a joint assessment of human and environmental health. Although this research phase was conducted as a pilot study, miners and health personnel alike requested a follow-up. As one professional nurse put it: 'I hope you will do the same in all mining communities in the area.'

How can we promote recognition, participation, and engagement? The main problem in Ghana, as stated by Hilson and Potter (2005, p. 127), is that the government lacks genuine interest in promoting the small-scale mining sector by turning 'a blind eye' to the needs of small operators while facilitating large-scale, multinational investments. Carson et al. (2005) recommend public-private partnerships that build stakeholder capacity, address knowledge barriers, support training of local environmental NGOs and community members, create participatory environmental monitoring systems, and include small-scale miners into the policy agenda. Simplified registration processes, secured tenure, and access to cheap finance for healthier technologies would also be required. Drawing upon the ecohealth approach, Spiegel and Veiga (2005) suggest transportable demonstration units for the ASM sector to link mercury pollution to intertwined health, environmental, and socio-economic challenges.

What is most urgent is to raise the profile of Ghanaian small-scale mining by accepting it as a viable livelihood option for thousands and an economic sector to be nurtured and engaged constructively. Currently, the discourse of marginalization and criminalization prevents any type of fruitful collaborative and long-term action. We have shown that the main predicament stems not so much from toxic contamination with mercury but from exclusion of most

small-scale miners from educational, health, technological, and financial services. Active involvement of mining communities into capacity building for enhanced human and environmental health is the first step out of the current impasse.

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References

- Adger, W.N., Benjaminsen, T.A., Brown, K., Svarstad, H., 2001. Advancing a political ecology of global environmental discourses. *Development and Change* 32 (4), 681–715.
- Adimado, A.A., Baah, D.A., 2002. Mercury in human blood, urine, hair, nail, and fish from the Ankobra and Tano River Basins in Southwestern Ghana. *Bull. Environ. Contam. Toxicol.* 68, 339–346.
- Agyeman, J., 2005. *Sustainable Communities and the Challenge of Environmental Justice*. New York University Press, New York and London.
- Amankwah, R.K., Anim-Sackey, C., 2004. Promoting cooperation between small- and large-scale miners in Ghana. *Mining Engineering* 56 (4), 36–39.
- Amegbey, N.A., Eshun, P.A., 2003. Mercury use and occupational exposure in the Ghanaian small-scale gold mining industry. *Ghana Mining Journal* 7, 54–61.
- Andrew, J.S., 2003. Potential application of mediation to land use conflicts in small-scale mining. *Journal of Cleaner Production* 11 (2), 117–130.
- Aryee, B.N.A., 2003. Small-scale mining in Ghana as a sustainable development activity: its development and a review of the contemporary issues and challenges. In: Hilson, G.M. (Ed.), *The Socio-Economic Impacts of Artisanal and Small-Scale Mining in Developing Countries*. A.A. Balkema Publishers, Lisse, The Netherlands, pp. 379–418.
- Babut, M., Sekyi, R., Potin-Gautier, M., Tellier, S., Bannerman, W., Casellas, C., Rambaud, R., 2001. US/GHA/99/128 – Assistance in Assessing and Reducing Mercury Pollution Emanating from Artisanal Gold Mining in Ghana – Phase I: Part II – Conduct of Surveys on River Systems & Overall Conclusions. UNIDO.
- Ballard, C., Banks, G., 2003. Resource wars: the anthropology of mining. *Annual Review of Anthropology* 32, 287–313.
- Bannerman, W., Potin-Gautier, M., Amoureux, D., Tellier, S., Rambaud, A., Babut, M., Adimado, A., Beinhoff, C., 2003. Mercury and arsenic in the gold mining regions of the Ankobra River basin in Ghana. *J. Phys. IV (France)*, 107. doi:10.1051/jp4:20030255.
- Beijer, K., Jernelov, A., 1979. Methylation of Hg in aquatic environments. *The Biogeochemistry of Mercury in the Environment*. Elsevier/ North-Holland Biomedical Press, Netherlands.
- Bonzongo, J.C., Donkor, A.K., Nartey, V.K., 2003. Environmental impacts of mercury related to artisanal gold mining in Ghana. *Journal de Physique IV* 107, 217–220.
- Bostrom, A., Morgan, M., Fischhoff, B., Read, D., 1994. What do people know about global climate change? 1. Mental models. *Risk Analysis* 6, 959–970.
- Carson, M., Cottrell, S., Dickman, J., Gummerson, E., Lee, T., Miao, Y., Teranishi, N., Tully, C., Uregian, C., 2005. *Managing Mineral Resources Through Public–Private Partnerships: Mitigating Conflict in Ghanaian Gold Mining*. Woodrow Wilson School of Public and International Affairs, Princeton, NJ.
- Crispin, G., 2003. Environmental management in small scale mining in PNG. *Journal of Cleaner Production* 11 (2), 175–183.
- Donkor, A.K., Nartey, V.K., Bonzongo, J.C., Adotey, D.K., 2006a. Artisanal mining of gold with mercury in Ghana. *West Africa Journal of Applied Ecology* 9, 1–8 (Paper 2).
- Donkor, A.K., Bonzongo, J.C., Nartey, V.K., Adotey, D.K., 2006b. Mercury in different environmental compartments of the Pra River Basin, Ghana. *Science of the Total Environment* 369, 164–176.
- Eisler, R., 2003. Health risks of gold miners: a synoptic review. *Environmental Geochemistry and Health* 25, 325–345.
- Forget, G., Lebel, J., 2001. An ecosystem approach to human health. *International Journal of Occupational and Environmental Health* 7 (2 Suppl), S3–S36.
- Fraser, N., 1998. Social justice in the age of identity politics: redistribution, recognition and participation. In: *The Tanner Lectures on Human Values*, vol. 19. University of Utah Press, Salt Lake City, UT.
- Fraser, N., 2000. Rethinking recognition. *New Left Review* (May/June), 107–120.
- General News, 2006. “Galamsey” – Now a Major Challenge to Mining Companies. September 14.
- Ghana Web, 2004. Illegal Mining a Threat in Ghana. October 10.
- Ghana Web, 2006. Golden Star Reports Government Intervention to Remove Illegal Miners from its Concessions in Ghana, November 2.
- Ghanaian Chronicle, 2005. Mining Cripples and Illegal Miners Resist Relocation. May 7, 2005.
- Golow, A.A., Adzei, E.A., 2002. Mercury in surface soil and cassava crop near an alluvial goldmine at Dunkwa-on-Offin, Ghana. *Bull. Environ. Contam. Toxicol.* 69, 228–235.
- Golow, A.A., Mingle, L.C., 2003. Mercury in river water and sediments in Some Rivers near Dunkwa-on-Offin, and alluvial goldmine, Ghana. *Bull. Environ. Contam. Toxicol.* 70, 379–384.
- Hammond, N.Q., Tabata, H., 1997. Characteristics of ore minerals associated with gold at the Prestea mine, Ghana. *Mineralogical Magazine* 61, 879–894.
- Heemskerk, M., 2004. Risk attitudes and mitigation among gold miners and others in the Suriname rainforest. *Natural Resources Forum* 27, 1–12.
- Heemskerk, M., 2005. Collecting data in artisanal and small-scale mining communities: measuring progress towards more sustainable livelihoods. *Natural Resources Forum* 29, 82–87.
- Hilson, G., 2001. A Contextual Review of the Ghanaian Small-scale Mining Industry. International Institute for Environment and Development, London, England.
- Hilson, G., 2002. Small-scale mining and its socio-economic impact in developing countries. *Natural Resources Forum* 26, 3–13.
- Hilson, G., 2006. Abatement of mercury pollution in the small-scale gold mining industry: Restructuring the policy and research agendas. *The Science of the Total Environment* 362 (1–3), 1–14.

- Hilson, G., Pardie, S., 2006. Mercury: an agent of poverty in Ghana's small-scale gold-mining sector? *Resources Policy* 31, 106–116.
- Hilson, G., Potter, C., 2003. Why is illegal gold mining activity so ubiquitous throughout rural Ghana? *African Development Review* 15 (2), 237–270.
- Hilson, G., Potter, C., 2005. Structural adjustment and subsistence industry: artisanal gold mining in Ghana. *Development and Change* 36 (1), 103–131.
- Hilson, G., Yakovleva, N., 2006. Strained relations: a critical analysis of the mining conflict in Prestea, Ghana. *Political Geography*, 1–22.
- Hilson, G., Hilson, C.J., Pardie, S., 2007. Improving awareness of mercury pollution in small-scale gold mining communities: challenges and ways forward in rural Ghana. *Environmental Research* 103 (2), 275–287.
- Hinton, J., Beinhoff, C., 2005. Report to the UNEP GC Meeting, Nairobi, February 2005, on Mercury and Artisanal Gold Mining. Global Mercury Project.
- Hinton, J.J., Veiga, M.M., Beinhoff, C., 2003a. Women, mercury and artisanal gold mining: risk communication and mitigation. *J. Phys. IV France* 107, 617–620.
- Hinton, J.J., Veiga, M.M., Veiga, A.T.C., 2003b. Clean artisanal gold mining: a utopian approach? *Journal of Cleaner Production* 11, 99–115.
- Hontelez, J., Bender, M.T., Jensen, G., Hrdinka, C., 2006. Environmental and Health NGOs Call for Immediate Adoption of Regulation Proposal on EU Mercury Export Ban and Storage of Surplus Mercury. Brussels, 7 September 2006.
- IARC, 1993. Mercury and mercury compounds. IARC Summary & Evaluations, vol. 58. International Agency for Research on Cancer.
- ILO, 1999. Social and labor issues in small-scale mines. Report for the Tripartite Meeting on Social and Labor Issues in Small-scale Mines, Geneva, 17–22 May 1999. International Labor Office.
- Kinniburgh, D.G., Kosmus, W., 2002. Arsenic contamination in ground-water: some analytical considerations. *Talanta* 58 (1), 165–180.
- Koterba, M.T., Wilde, F.D., Lapham, W.W., 1995. Ground-water data-collection protocols and procedures for the national water-quality assessment program: collection and documentation of water-quality samples and related data. U.S. Geological Survey Open-File Report 95-399. Reston, 123 pp.
- Kull, A.C., 2002. Madagascar aflame: landscape burning as a peasant protest, resistance, or a resource management tool? *Political Geography* 21, 927–952.
- Kuma, J.S., 2004. Is groundwater in the Tarkwa gold mining district of Ghana potable? *Environmental Geology* 45, 391–400.
- Lacerda, L.D., Salomons, W., 1998. *Mercury from Gold and Silver Mining: A Chemical Time Bomb?* Springer, New York.
- Lambert, T.W., Guyn, L., Lane, S.E., 2006. Development of local knowledge of environmental contamination in Sydney, Nova Scotia: environmental health practice from an environmental justice perspective. *Science of the Total Environment* 368, 471–484.
- Lebel, J., 2003. *Health: An Ecosystem Approach*. Ottawa, Canada: International Development Research Centre. URL: www.idrc.ca/openbooks/012-8/.
- Mate, K., 1999. Boom in Ghana's golden enclave. UN Office of Communications and Public Information. <<http://www.un.org/eco-socdev/geninfo/afrec/vol11no3/ghanagold.htm>>.
- Mayer, D.D., 1996. The political ecology of disease as one new focus for medical geography. *Progress in Human Geography* 20 (4), 441–456.
- McDonald, D.A. (Ed.), 2002. *Environmental Justice in South Africa*. Ohio University Press, Athens, OH.
- Mining News, 2006. Small-scale Mines. The Ghana Chamber of Mines 2(2), June, p. 6.
- Morgan, M.G., Fischhoff, B., Bostrom, A., Atman, C.J., 2002. *Risk Communication: A Mental Models Approach*. Cambridge University Press, Cambridge, UK.
- Neumann, R.P., 1998. *Imposing Wilderness*. University of California Press, Berkeley, CA.
- Peluso, N.L., 1992. *Rich Forests, Poor People*. University of California Press, Berkeley, CA.
- Porcella, D.B., Ramel, C., Jernelow, A., 1997. Gold mercury pollution and the role of gold mining: an overview. *Water, Air and Soil Pollution* 97, 205–207.
- Quinn, C.H., Huby, M., Kiwasila, H., Lovett, J.C., 2003. Local perceptions of risk to livelihood in semi-arid Tanzania. *Journal of Environmental Management* 68, 111–119.
- Rambaud, A., Casellas, C., Sackey, S.O., Ankrah, N.-A., Potin-Gautier, M., Tellier, S., Bannerman, W., Babut, M., 2000. US/GHA/99/128 – Assistance in Assessing and Reducing Mercury Pollution Emanating from Artisanal Gold Mining in Ghana – Phase I: Part I – General Introduction and Assessment of Human Health. UNIDO.
- Rapport, D.J., Mergler, D., 2004. Expanding the practice of ecosystem health. *EcoHealth* 1 (Suppl 2), 4–7.
- Regional News, 2006. Illegal mining destroying farmlands in Talensi-Nab-Dam District, Friday, November 10.
- Reuters, 2006. Ghana gold diggers pose headache for mining firms, May 20.
- Richmond, C., Elliott, S.J., Matthews, R., Elliott, B., 2005. The political ecology of health: perceptions of environment, health and well-being among 'Namgis First Nation'. *Health & Place* 11, 349–365.
- Roe, E., 1991. "Development narratives" or making the best of blueprint development. *World Development* 19 (4), 287–300.
- Ryan, O., 2006. Ghana gold diggers pose headache for mining firms. Reuters, May 19, 2006.
- Schlosberg, D., 2003. The justice of environmental justice: reconciling equity, recognition, and participation in a political movement. In: Light, A., de-Shalit, A. (Eds.), *Moral and Practical Reasoning in Environmental Practices*. MIT Press, Cambridge, MA/London, England, pp. 77–106.
- Schlosberg, D., 2004. Reconceiving environmental justice: global movements and political theories. *Environmental Politics* 13 (3), 517–540.
- Schlosberg, D., 2007. Defining environmental justice: theories, movements, and nature. In: Paper Presented at the Annual Meeting of the Association of the American Geographers, April 17–21, 2007, San Francisco, CA.
- Shi, G., Jiang, G., 2002. A dip-and-read test strip for the determination of mercury(II) ion in aqueous samples based on urease activity inhibition. *Analytical Sciences*, 1215–1219.
- Sinding, K., 2005. The dynamics of artisanal and small-scale mining reform. *Natural Resources Forum* 29 (3), 243–252.
- Spiegel, S.J., Veiga, M.M., 2005. Building capacity in small-scale gold mining communities: health, ecosystem sustainability, and the Global Mercury Project. *EcoHealth* 2, 361–369.
- Spiegel, S.J., Savornin, O., Shoko, D., Veiga, M.M., 2006. Mercury reduction in Munhena, Mozambique: homemade solutions and the social context of change. *International Journal of Occupational and Environmental Health* 12 (3), 215–221.
- Tschakert, P., 2007. Views from the vulnerable: understanding climatic and other stressors in the Sahel. *Global Environmental Change*. doi:10.1016/j.gloenvcha.2006.11.008.
- van Geen, A., Protus, T., Cheng, Z., Horneman, A., Seddique, A.A., Hoqueand, M.A., Ahmed, K.M., 2004. Testing groundwater for arsenic in Bangladesh before installing a well. *Environ. Sci. Technol.* 38, 6783–6789.
- van Geen, A., Cheng, Z., Seddique, A.A., Hoque, M.A., Gelman, A., Graziano, J.H., Ahsan, H., Parvez, F., Ahmed, K.M., 2005. Reliability of a commercial kit to test groundwater for arsenic in Bangladesh. *Environ. Sci. Technol.* 39, 299–303.
- Veiga, M.M., Baker, R., 2004. *Protocols for Environmental and Health Assessment of Mercury Released by Artisanal and Small Scale Miners*, report to the Global Mercury project: removal of barriers to introduction of cleaner artisanal gold mining and extraction technologies. GEF/UNDP/UNIDO. 170 p. Available: <http://www.globalmercury.org>.
- Veiga, M.M., Maxson, P.A., Hylander, L.D., 2006. Origin and consumption of mercury in small-scale gold mining. *Journal of Cleaner Production* 14, 436–447.

- Vieira, R., 2004. Mercury-free gold mining technologies: possibilities for adoption in the Guianas. WWF Guianas Regional Program Office Technical Paper Series #1, WWF Guianas, Suriname.
- Vieira, R., 2006. Mercury-free gold mining technologies: possibilities for adoption in the Guianas. *Journal of Cleaner Production* 14 (3–4), 448–454.
- Walker, G., Bulkeley, H., 2006. Geographies of environmental justice. *Geoforum* 37, 655–659 (Editorial).
- Walker, G., Eames, M., 2006. Environmental inequalities: Cross-cutting themes for the ESRC/NERC transdisciplinary seminar series on environmental inequalities 2006, p. 8.
- Wing, S., 2005. Environmental justice, science, and public health. *Environmental Health Perspectives. Essays on the Future of Environmental Health Research*, 54–62.
- Yakubu, B.R., 2002. Towards sustainable small scale mining in Ghana. In: Barning, K., Dorgbetor, B. (Eds.), *Proceedings of the National Mining Conference on Mining, the Environment and Sustainable Development*. Published by the MC, Accra.
- Young, I.M., 1990. *Justice and the Politics of Difference*. Princeton University Press, Princeton, NJ.