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# Regulation of Artisanal Small Scale Gold Mining (ASGM) in Ghana and Indonesia as Currently Implemented Fails to Adequately Protect Aquatic Ecosystems

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**Abstract** Artisanal small scale gold mining (ASGM) operations are largely unregulated, informal and transient. Rudimentary mining and processing techniques used in ASGM often result in degraded environmental, safety, health and social conditions. ASGM requires permanent sources of water, placing most operations close to natural water bodies. Until recently, the impact on these environments has been largely overlooked, with most studies focussing primarily on mercury contamination and health concerns. Based on Ghanaian and Indonesian experiences, regulation of ASGM is a good step toward improvement, but here we argue that regulation alone is insufficient to improve environmental performance, particularly when the impacts of ASGM on aquatic ecosystems are largely unknown.
**Keywords** mercury, mine water, mine closure, sustainability, ASGM

## Background

The international mining industry is increasingly regulated and required to implement stringent procedures to prevent or mitigate its environmental impacts (Jones & Salmon 2012). In contrast, poverty, high commodity prices and poor governance have attracted many people in developing countries to the largely unregulated artisanal gold mining (ASGM). Currently ASGM activity is documented in more than 70 countries and provides direct employment to at least 15 million people and indirect employment to more than 100 million people around the world (WHO 2013). ASGM generally refers to gold mining by individuals, groups, families or cooperatives with rudimentary mining and processing methods (Hentschel et al. 2002). An ASGM operation can be formal (registered business) or informal, but the sector is typically unorganized and without external investment. The combination of these factors explains much of the low productivity in ASGM (ILO 1999), while the lack of long term planning highlights its unsustainable nature (Hinton, Veiga, Veiga 2003). Due to an intrinsically poor geological exploration capacity, ASGM typically operates in areas where mineable reserves are known, usually discovered by larger commercial mining companies with legal concessional titles of the land. The presence of ASGM in such areas often creates additional legal, social and environmental conflicts to existing regulated mining operations (Aspinall & Eng 2001, Hinton et al. 2003). AGSM activities near to regulated mines may also complicate regulation of these mines and their operational and closure environmental and social performances (Aspinall & Eng 2001, Mauric et al. 2012). Mercury use in ASGM is particularly problematic due to its toxicity as well as sheer amount of emission. In 2010 UNEP estimated the annual mercury emission by ASGM to be 727 tonnes, or 35% of the total world anthropogenic emission of mercury (UNEP 2013).

## ASGM mining and processing methods

ASGM operators usually work on secondary or tertiary alluvial ores easily found in river sediment by panning, dredging, or hosting sediments down river banks or open pits using high pressure pumps. More recently, ASGM operators have been working on primary ore mined underground, typically by manual digging of vertical shafts or tunnels up to 30 to 35 meters deep. Loose gravel, sands and milled ores in ASGM are usually processed via semi-mechanical crushing, elutriation and, in most cases, mercury amalgamation followed by gold smelting and refining. During the processes, most ASGM emits mercury to the environment by (1) disposal of mercury-laced tailings and process water to the ground and water bodies, and (2) atmospheric emission of mercury vapours from the smelting of the gold-mercury amalgam. The amount of mercury used and emitted into the environment by ASGM is often determined by the type of processing method rather than regulatory requirements. For example, the total mercury used in and emitted by the whole ore amalgamation method widely practised in Indonesia, is substantially more than that of the partial gravity-amalgamation method commonly used in Ghana.

Processing with cyanide has been introduced to ASGM operators as an alternative to mercury amalgamation because unlike mercury, cyanide breaks down rapidly and does not bio-accumulate as readily. The cyanide processing, however, still not preferred amongst smaller operators because it requires larger capital investment and production scales (Sousa et al. 2010, Sulaiman et al. 2007). It is, however, common practice for ASGM processors in Indonesia to sell their mercury-laced tailings to larger ASGM operators or processing centres to be reprocessed with cyanide. In North Sulawesi, Indonesia, two thirds of gold produced in the area is obtained by cyanidation of these tailings (Sulaiman, et al. 2007). In Ghana, tailings from ASGM are also illegally sent to larger processors elsewhere in the country as well as neighbouring countries such as Burkina Faso and Cote d'Ivoire for cyanidation. The mercury-cyanide complexes resulting from these larger processors potentially create more pollutions which are yet to be established (Veiga et al. 2014).

## Legal framework of ASGM

The legality of ASGM varies among countries, with some providing a legal framework for small scale mining activities, and others simply banning such activities. In an effort to manage and promote an efficient ASGM sector, the Ghanaian and Indonesian Mining Laws, for example, have provisions for small scale mining. The Ghanaian Mining Act (2006) and Indonesian Mineral and Coal Law (2009) stipulate that Ghanaian and Indonesian citizens, as individuals or cooperatives of up to ten people, can apply for a licence to mine on a maximum of10 Ha land in areas designated for small scale mining. In Ghana, extension offices of the Minerals Commission comprising representatives of several governing agencies (e.g., the Environmental Protection Agency and Precious Metals Marketing Company) have been formed in the nine main ASGM regions to process AGSM mining applications as well as monitor activities (such as mercury trade control) and purchase gold (Mr. Kofi Tetteh, Minerals Commission 2014. pers. com.). In Indonesia, while a mechanism of licensing, permitting, management and control of small scale mining is not clearly stipulated, the management and control of ASGM is fully decentralized to regional governments. The use of mercury in mining is illegal in Indonesia (signatory to the 2013 UNEP International Treaty on Mercury), while limited use of mercury in ASGM is legal in Ghana.

Despite the regulatory attempts to legalise ASGM operations in Ghana and Indonesia, ASGM continue to grow, mostly illegal due to operators' lack of permits and/or mine concessions / rights, or the use/misuse of controlled substances such as mercury or cyanide. Miners have found permits and licences hard and expensive to acquire while law enforcement is poor and often unevenly applied. In Ghana, according to a 2008 report by the Ghana Chambers of Mines, there were only 300 registered ASGM operators in Ghana, and between 300,000 to 500,000 miners currently in operation – a clear sign of ASGM persistence, despite government regulatory efforts (Bush, 2008). The latest (2013) enforcement effort in Ghana included the arrest and deportation of almost 4000 foreigners working directly or indirectly in ASGM which resulted in a temporary cessation of many operations around the country (Mensah 2013). However, personal observations by the author (FM) of ASGM communities in Ghana showed that operations were rapidly reinstated, this time being run mostly by local citizens. In Indonesia, illegal ASGM grew from 50,000 miners operated in 576 areas in 2006 to 250,000 miners operated in about 800 areas in 22 provinces in 2010 (Ismawati 2014). The decentralization of authority to the local governments in Indonesia was seen as a significant contributing factor to the unintended growth in illegal ASGM.(Gita et al. 2012).

While the regulations pertinent to ASGM in Indonesia and Ghana require monitoring and control of mining operations, the impacts of ASGM on aquatic ecosystems are often under monitored or not monitored at all. The illegality of most ASGM operators makes it even harder for these impacts to be monitored. The regulatory requirements of ASGM operators to perform environmental impact assessments often do not fit within the reality of ASGM, as operators lack capacity to produce impact assessments. Essentially, like many governments in developing countries where ASGM commonly is found, Ghana and Indonesia lack the institutional and technical capacity to provide adequate assistance to assess impacts or enforce compliance, especially at the local and regional levels (Sousa et al. 2011). A lack of information and data about AGSM practises adds to the challenges in implementing environmental management and due diligence principles (Hilson 2005). The sheer numbers of ASGM miners and locations, combined with the poorly understood temporal and spatial variability of impacts on aquatic ecosystems complicate efforts of local and regional environmental managers to regulate activities.

## The impacts of ASGM on aquatic ecosystems

The toxicity of mercury to people involved with ASGM and, to a lesser extent, to the environment, has been well studied (Bose-O'Reilly et al. 2010; Castilhos et al. 2006; Donkor et al. 2006). As most ASGM operations occur near to lakes or along streams and rivers for easy access to water needed for operations, its impacts on aquatic ecosystems can be significant (fig.1). The impacts of ASGM on aquatic ecosystems vary both spatially and temporally due to the volume and concentration of contaminants being released. During the dry season, ASGM operators draw water from the nearest water bodies for processing. In the wetter seasons, run-off from unregulated ASGM elutriation boxes, slurry channels and sumps, tailing dumps and open pits elevates turbidity, total suspended solids, trace metals and nutrients in streams and rivers, resulting in sedimentation and changes to river morphology and water quality. In addition to reduced water quality, changes in water quantity of aquatic systems may occur, due to the large volume of untreated mine water pumped directly out of mine pits and shafts into rivers or other water bodies. The Ghana Water Company who supplies water for domestic and industrial purposes has complained of increased costs of treatment due to elevated contaminants in raw water drawn from rivers impacted by ASGM (Srem & Andoh, 2013).

## Conclusion

Regulations on ASGM alone have proven ineffective in curbing impacts to aquatic ecosystems. To be effective, the regulations should be accompanied by a comprehensive approach that includes training and educational programs, targeted at miners, processors and local/regional authorities, toin recognise, control and monitor impacts. While studies in impacts of ASGM mercury on the environment and human health remain important, studies and efforts to find effective methods to prevent, identify, monitor and control other ASGM pollutants and processes affecting waterways (e.g., sedimentation, alterations in flow regime) are needed. Practical, economical and appropriate aquatic environmental monitoring measures should be introduced to environmental managers at local and regional levels while use of cleaner methods can be gradually introduced to miners. Such efforts are particularly relevant in the developing countries like Ghana and Indonesia where lack of clean water supplies is part of a greater sustainability issue.

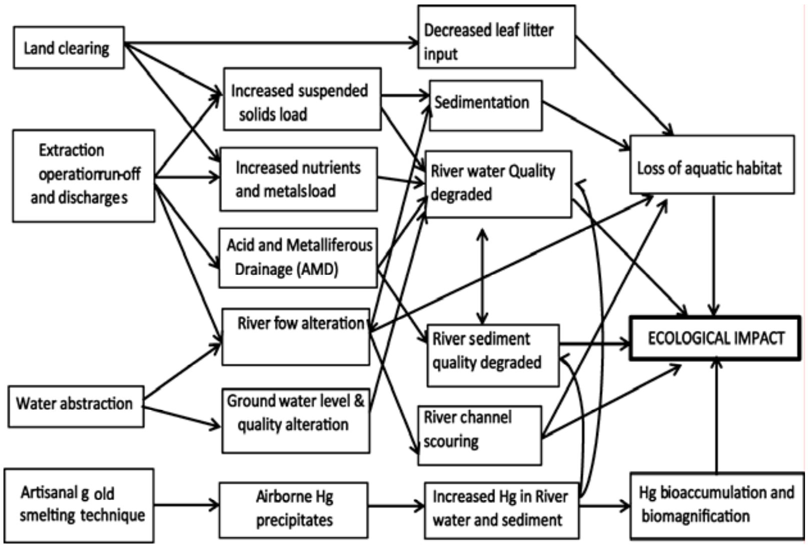


***Fig. 1.*** *The impacts of artisanal small-scale gold mining (ASGM) on riverine systems*


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