

Mercury in different environmental compartments of the Pra River Basin, Ghana

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Abstract

Artisanal gold mining (AGM) with metallic mercury has a long history in Ghana. It is believed to be over 2000 years old. Today, AGM has escalated in a new dimension consuming about half of the country where gold lode deposits exist along riverbanks or rivers are alluvial-gold rich. The Pra River in southwestern Ghana is a site of on going application of metallic mercury in prospecting gold, and this paper examines mercury (Hg) contamination in the different environmental compartments in its watershed. Samples of water, sediment, soil and biota (i.e., human hair and fish) were collected from locations along the course of the river during the rainy and dry seasons of 2002 and 2003, respectively. Besides the obvious Hg point sources along the Pra and its tributaries, the obtained results show that Hg levels and speciation in the studied aquatic system are controlled by precipitation, which drives the hydrology and differences in flow regimes versus seasons. The seasonal difference in Hg speciation suggests that methyl mercury (MeHg) found in the aqueous phase and riverine sediments is likely of terrestrial origin where its production is favored during the rainy season by high soil water and organic matter content. The use of the enrichment factor (EF) for the assessment of sediment quality indicated moderate to severe contamination of surface sediments in the rainy season, while in the dry season, the EF index indicates nearly no pollution of surface sediments. Accordingly, most of the Hg introduced into this river system is likely transported to depositional downstream terminal basins (e.g. the river delta and the Gulf of Guinea). With regard to biota, Hg measured in hair in the dry period was higher than data obtained on samples collected during the wet period. This could be explained at least in part by the shift in diet as a result of abundance of fish in the local markets and the concurrent increase and more active fishing during the dry season. Mercury data obtained on a very limited number of fish samples collected during the dry period only are also presented.

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1. Introduction

The mining of gold by mercury (Hg) amalgamation technology has been known since ancient times. The inexpensive nature of this amalgamation technique

yoked with the easier to use and quite efficient gold recovery makes it to be the method of choice for current small-scale gold mining nations in the developing world. And the socio-economic merits of gold production by this methodology is obvious today; nevertheless, artisanal gold mining (AGM) with Hg faces strong opposition by the international community. This is primarily due to the toxicity of alkyl-Hg

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compounds, namely MeHg, which bio-accumulates and results in deleterious effects on biota and ecosystem functions. Past Hg incidents are the Hg disaster in Minamata, Japan in the 1950s (Klein and Goldberg, 1970; D'Itri and D'Itri, 1977) and Hg food poisoning reported in Iraq, Pakistan, Ghana and Guatemala (Bakir et al., 1973; Derban, 1974; Ehrlich, 2002), which resulted in numerous deaths. Following these fatal incidents, developed countries outlawed and moved on to phase out the use of Hg in both mining and several non-mining industrial activities. However since the advent of the new gold rush in the 1980s, thanks to socio-economic predicaments common to most developing nations, the use of Hg to mine gold has rebound and heightened in spite of the inception of cyanidation technology. This is the situation in Ghana presently; AGM with Hg has escalated in a new dimension consuming about half of the country where riverine sediments and riverbank materials are rich in gold.

In Ghana, gold mining by Hg amalgamation was given a booster in 1989 following its legalization by the government (Addy, 1998; Bonzongo et al., 2004; Donkor et al., in press). This type of mining is believed to be over 2000 years old; with Ghana earning the name “*Gold Coast*” when the Europeans arrived witnessing the land’s vast wealth of gold and the indigenous gold industry being manned by Ghanaians in their own simple way (Kesse, 1985). Currently, the bulk of the gold production in Ghana comes from goldfields in the southwestern part of Ghana, which is drained by three main rivers comprising of the Tano, the Ankobra, and the Pra. Inevitably, Hg from process wastes is released to rivers and accumulated in mine tailings along riverbanks. Unfortunately, in Ghana, high annual precipitation and the resulting active fluvial processes are likely to exacerbate the widespread contamination of aquatic systems by Hg. Accordingly, one would expect Hg to be transported from mining sites from river upstream reaches to downstream depositional areas including the river delta and the Gulf of Guinea, which are economically important fishing areas.

In this paper we report on Hg levels, speciation, and distribution along longitudinal transect in the Pra River system. Hg was determined on water, sediment, soil, and biota samples collected during both the wet or rainy and dry seasons. Our findings suggest that for a river system impacted by gold mining by Hg amalgamation for several centuries, Hg levels in different environmental compartment are rather low, although there is a clear evidence of Hg contamination.

2. Materials and methods

2.1. Study area

Ghana is located in the western portion of the African continent, which lies along the Gulf of Guinea. Ghana is bounded in the east by the Republic of Togo, on the west, is Ivory Coast and on the north, is Republic of Burkina Faso. The climate is tropical and humid with temperatures varying between 24 to 28 °C in the south. The study area is the southwestern part of Ghana where most of the gold mines are located, representing an area of 40,000 km². In this region, the geology is dominated by the Birimian and Tarkwaian formations (Kesse, 1985; Dumett, 1998). Most of the rocks in this part of Ghana have been formed through re-deposition as placer gold deposits (also known as “alluvial gold”), due to a series of erosional events. These are found in many of the rivers draining the Birimian rocks or the gold belt particularly the three major rivers: Pra and its tributaries, Ankobra, and Tano (Kesse, 1985; Dzignodi-Adjimah and Bansah, 1995; Oberthur et al., 1997). Accordingly, small-scale gold mining is restricted to these areas. Gold output from this region, according to Addy (1998) accounts for 81% of Ghana’s production and AGM contributes only 10% of the annual tonnage of gold in Ghana with the rest coming from commercial ventures (Adimado and Baah, 2002).

Our investigations were conducted along the Pra River, which takes its source from Kwahu Plateau before joining by the main tributaries rivers Offin and Birim to enter the Gulf of Guinea (Fig. 1). Nearly the entire Pra Basin is spotted with active AGM sites.

2.2. Sampling

During the rainy season of 2002 and the dry season of 2003 in Ghana, water, sediments, soils, and human hair were collected along longitudinal transects in the Pra River and its watershed. Samples were collected from a total of 21 sites including locations near past and current AGM sites and locations far up or downstream of current and active mining centers. The 21 sampling sites were selected on the Offin, the Upper Pra, and the Lower Pra (see Fig. 1). From these sites, surface water samples were collected from headwaters upstream of known present and historic mining sites to near the river delta. Sampling sites also included points of connection between streams and canals connecting mining sites/ponds to the Pra. Water samples were collected directly into acid pre-cleaned Teflon® bottles, using the “ultra-clean free-metal sampling” protocol as described

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