Multi-scale Evaluation of Environmental Degradation Resulting from Surface Gold Mining in Ghana

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Introduction: Industrial and small-scale mining industries in Ghana have provoked environmental degradation in the form of deforestation, soil erosion, and soil and water contamination by heavy metals. The first significant impact of mining is the destruction of forest land to access gold deposits. Once vegetative cover is removed, soil degradation occurs in the form of accelerated water erosion, soil compaction, and soil crusting. These processes lead to loss of productivity and land alienation. During ore crushing and panning, which are processes used in gold extraction by local artisans, Pb, As, Cu, and other heavy metals associated with gold are released into the environment. Mercury, which does not occur naturally in most gold mining sites, is introduced into the environment during gold processing to amalgamate the gold. Remote sensing and GIS technologies were used to investigate the temporal and spatial extent of environmental degradation from 1986 to 2001 in the Tarkwa mining area (Figure 1). The environmental impact of gold mining was also determined by analyzing mine tailings from the following communities in Ghana: Obuasi, Baako Akohu, Senyakrom, and Tamso sites (Figure 1). This study puts into perspective the need for the government to institute regulations to protect mining areas.

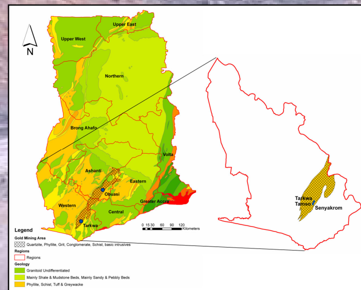

Figure 1: Map of Ghana and mining study area.

Purpose of Study: Document and quantify the environmental impact of the multinational and small scale gold mining industries in a Ghanaian gold mining area.

Temporal and Spatial Methods: Landsat TM and ETM+ data were obtained from June 1986 and June 2001. The images were radiometrically corrected, and pre-processed to remove clouds and scan lines. The images were subset from the floating scene to identify Tarkwa and its environs, and displayed as false color composite with band combinations with 4 as red, 3 as green, and 2 as blue. The images were later enhanced using histogram equalization and classified using unsupervised classification technique.

Analysis of Tailings: Samples were collected from piles of tailings at the four sites. At each location, samples were taken from two heaps at the following depths: 0-10, 10-20, and 20-30 cm. Samples were analyzed for particle size, pH, and heavy metals.

Results from Temporal and Spatial Study: Remote sensing and GIS technology indicated that degradation in the Tarkwa region is extensive. All forests in the region were destroyed between 1986 and 2001 (Figure 2, Table 1). While most of the study area was a healthy ecosystem in 1986, by 2001, over 60% of the land was degraded to the point where it could not be used for any commercial activity. An additional 35,000 ha of land has been polluted and remediation will be very expensive.

Results from Tailings: The tailings from Obuasi, Baako Akohu, Senyakrom, and Tamso sites were generally sandy (Figure 3). The sites varied from highly acidic at Tamso to alkaline at Obuasi (Figure 4). The tailings from Obuasi could have the most significant negative impact on environmental integrity. They contained the highest amounts of As (2,409 $mg\ kg^{-1}$), Cu (108 $mg\ kg^{-1}$), and Pb (49.5 $mg\ kg^{-1}$) (Figures 5,6). Small scale gold mining at Tamso and Senyakrom sites generated tailings with elevated levels of As and Hg. The enrichment ratios for these metals (As, Hg, and Pb) were greater than 10 across all sampling locations. The threat of pollution at Tamso and Senyakrom is further exacerbated by the low pH values of the tailings which enhances the mobility of heavy metals. Tailings from Baako Akohu were almost neutral in pH and were generally low in heavy metals.

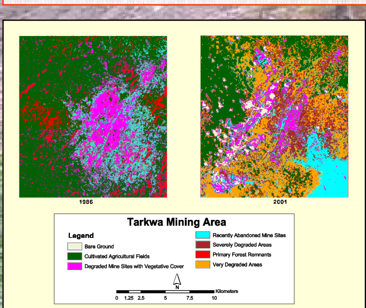

Figure 2: Land cover classes in the Tarkwa mining area.

Table 1: Land cover classes in the Tarkwa mining area.

Land Cover	1986	2001
Primary Forest	20,727	0
Cultivated agricultural fields	148,964	71,584
Recent abandoned mine sites	48,067	29,760
Degraded mine sites with vegetative cover	0	24,553
Very degraded areas	0	71,984
Severely degraded areas	31,967	41,874
Bare areas	0	9,968

*Columns with the same letter are not statistically different.

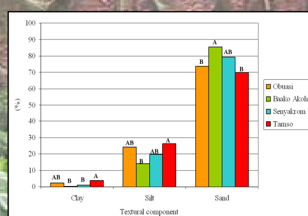

Figure 3: Average particle size distribution of the mine tailings.

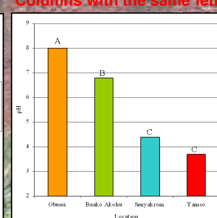

Table 4: Average pH of the mine tailings.

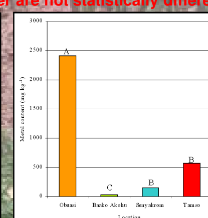

Figure 5: As concentrations in the mine tailings.

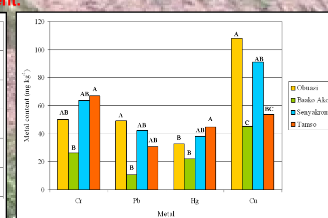

Figure 6: Heavy metal concentrations in the mine tailings.

Conclusions:

1) Remote sensing permits the evaluation of degradation due to surface mining.
2) Small scale gold mining is a potential source for heavy metal pollution in the environment.