ISSN 1848-0071
546.19(668.1)=111
Recieved: 2014-02-27
Accepted: 2014-06-04
Professional paper

MINING RELATED ARSENIC PROBLEMS IN GHANA

CRENTSIL KOFI BEMPAH

Faculty of Environmental Sciences and Process Engineering, Technical University, Cottbus, Germany
e-mail: bempacre@tu-cottbus.de

Ghana is Africa's second-largest gold producing country after South Africa. Most mining areas particularly in Ashanti Region (Obuasi) and Western Region (Tarkwa), until the introduction of the bio-oxidation (BIOX) technology of extracting gold, the processing of the ore for gold involved the crushing and grinding of ore to fine powder followed by dissolution and precipitation of free gold. During the ore preparation by roasting, sulphur dioxide and As trioxide were released into terrestrial and atmospheric environments. As rich tailings heaped and kept in dams were left at the mercy of the rain with subsequent leaching into rivers, streams and aquifers. Other mine wastes as particulates were transported far and near through the air. There is also continuous wet and dry deposition of particles unto land, water and plants. Humans and animals are exposed to As through drinking, diet and inhalation.
Key words: mining, arsenic, environment, gold deposits, heavy metals, Ghana.

Problemi vezani uz arsen u rudarstvu Gane. Gana je drugi po veličini proizvođač zlata u Africi, poslije Južnoafričke Republike. U većini rudarskih područja, posebno u regiji Ashanti (Obuasi) i zapadnoj regiji (Tarkwa), do uvođenja u bio-oksidacijske (BIOX) tehnologije izdvajanja zlata, u obradi rude pri proizvodnji zlata bilo je drobljenje i mljevenje rude u fini prah, te potom izluživanje i taloženje zlata. Tijekom obrade rude prženjem, sumporni dioksid i arsenov (III) oksid se ispuštaju u zemlju i atmosferu. Bogate nakupine mulja prepuštene su djelovanju kiše i posljedičnom ispiranju u rijeke, potoke i druge vodotoke. Drugi rudarski otpad odlazi zrakom u neposrednu i širu okolicu. Tu je i kontinuirano mokro i suho taloženje čestica u zemlju, vode i u biljke. Ljudi i životinje su izloženi arsenu i kroz piće, prehranu i udisanje.
Ključne riječi: rudarstvo, arsen, okoliš, nalazišta zlata, teški metali, Gana.

INTRODUCTION

Ghana, formerly the Gold Coast, is an important gold mining country located in the western part of sub-Sahara Africa. Gold mining in the Ashanti Region dates back to the 19th century. The mining is believed to have started 1890 by three Fante concessi-onaires: Joseph Edmund Biney, Joseph Elttruson Ellis and Joseph Peter Brown. Edwin Cade later bought the mine from them with government's recognition of his agreement, to form the new company called Ashanti Goldfields Corporation (AGC) established in June 1897. A lease period for 90 years was granted to AGC by the government. The mineral concession covered 259 km^2 [1].

In January 1969, the Corporation was taken over by Lonhro Limited from Britain. The government of Ghana then extended the period of the lease by 50 years (ending in 2018) with 20 % holding of Ashanti shares in the new agreement. However in October

1st, 1972, under the Mining Operations (Government Participation) Decree (N.R.C.D. 132), AGC became Ashanti Goldfields Corporation (Ghana) Limited [1] with the government of Ghana having 55 % share. Until its merger in 2004 as AngloGold Ashanti, the corporation remained jointly owned by government of Ghana and Lonrho from Britain.

AngloGold Ashanti mine accounts for more than 50 % of the total annual gold production in the country. Gold brings about 45 % of the total export revenue to the nation [2-3]. Nevertheless, mining and processing of the ore have contributed immensely to environmental degradation and pollution in the area.

MAJOR GOLD MINING LOCATIONS

The Ashanti and Western regions are the major gold mining locations. The gold (Au) is associated with sulphide mineralization, particularly arsenopyrite [4]. The belief is that the Birimian formation has over ten times the average crystal abundances of Au and arsenic [1].

The gold deposits at the study area are part of a prominent gold belt of Proterozoic (Birimian) volcano sedimentary and igneous formations, which extend for a distance of approximately 300 kilometers in a northeast southwest trend in southwestern Ghana. The area mineralization is shear zone-related, and there are three main structural trends hosting gold mineralization: the Obuasi trend, the Gyabunsu trend and the Binsere trend. Two main ore types are mined:

- quartz veins, which consist mainly of quartz with free gold in association with lesser amounts of various metal sulfides, such as iron, zinc, lead and copper. The gold particles are generally fine-grained and occasionally are visible to the naked eye;
- sulfide ore, which is characterized by the inclusion of gold in the crystal structure of a sulfide material. The gold in these ores is fine-grained and often locked in arsenopyrite. Higher gold grades tend to be associated with finer-grained arsenopyrite crystals. Other prominent minerals include quartz, chlorite and sericite [5].

Due to the nature of the gold ore and the previous method of mining and processing of the metal, environmental degradation and metal pollution are restricted to only mining areas especially Obuasi, Prestea and Tarkwa. Mining operations going on in the south-western part of Ashanti Region, particularly Obuasi have been identified as one of the major driving forces causing rapid land-cover changes (the second driving force is urbanization). This confirms a report that the upsurge of gold mining has resulted in the increase in gold production from an annual total of more than 1.2 million troy ounces, which established Ghana as Africa’s second largest gold producer, after South Africa [6]. Moreover, the AngloGold Ashanti Company also confirms that mining in the area has grown over the time and artisanal and small-scale miners are those who encroach illegally onto the company-owned land in their search for minerals. Thus the barren land is seen to have increased from 2002 to 2008, while farmland in this period is found to have big lost to barren land, because illegal miners, in their search for gold, leave the land surface bare after exploiting it. Nonetheless, AngloGold Ashanti has maintained large tracts of teak plantation as green belt covering 12.10 km^2 within its concession [7].

ARSENIC CAUSING ENVIRONMENTAL DAMAGE

Environmental damage caused by arsenic has also been documented in those areas, although there is currently little evidence of detrimental effects on human health. Hence arsenic mobilizes in the environment as a result of arsenopyrite oxidation induced by mining activities (especially dispersal of tailings). The degeneration of the Ghanaian mining environment by mine chemical wastes is principally the consequence of poor management of mine spoil facilities and the reckless manner in which alluvial and open pit activity are carried out. Consequently, arsenic trioxide and sulphur dioxide have been discharged directly into the Obuasi countryside particularly for the past 50 years and this poor environmental practice has had adverse impacts on the environment.

Arsenic is mobilized in the environment as a result of oxidation of arsenopyrite. High arsenic concentrations has been reported in the soils (Amasa), and rivers (Smeldley) close to the mining operations and ore processing plant. At the AngloGold Ashanti mine, the long period of mining and metallurgic activities have resulted in increased concentrations of the physico-chemical parameters in water bodies, as well as degradation of agricultural lands (Anon).

For example, from 1947 until 1992, effluents were discharge without precaution, thereby resulting in the degeneration of the environment (Carboo, Tufour, Tsidzi). Exploitation of hitherto low-grade ore as a result of the Ashanti Mine Expansion Programme (AMEP) caused increased mining activities, hence increased chemical contamination at the Obuasi mine and its satellite areas (Anon). AMEP was part of the several responses of the Ghanaian Mining Industry Policy Initiative to promote investment in the sector. Unfortunately, these initiatives were rather weak on the provision of guidelines for the management of the associated negative environmental impacts (Akabzaa).

Around the town of Obuasi, Prestea and Tarkwa studies in these locations revealed high As concentration in water, soil, fruits, food crops, biological tissues, rivers, school compounds, farmlands and settlements close to the mine sites [8 - 20].
Heavy metals in stream water and sediments in south-western part of Ashanti Region abound in the literature. Akabzaa measured high concentrations of heavy metals in the environment and indicated that heavy metals such as iron (Fe) and As had ranges of 2210-50180 mg/kg and 0.24-7592 mg/kg in sediments and 0.26-17.19 mg/L and <0.01-6.32 mg/L in water respectively. These researchers also concluded that such high metal values in sediments are the results of high tropical rainfall, which could result in sporadic regimes of re-suspension of the stream and over-bank sediments when river flow increases.

Amonoo-Niezer [10] also investigated mercury (Hg) and As pollution on soils, food crops and fish in and around the mining town of Obuasi recording unimaginable levels of As. Similar studies by Amasa [21] and Amonoo-Niezer [19] gave large quantities of As in soils, crops and vegetation in localities far and near the mine centers. Amonoo-Niezer and Amekor [11] had ascertained that As content of some environmental samples, particularly water was too high making it dangerous to aquatic life, or for domestic use.

Akabzaa [16] assessed As and other heavy metals in the mining communities within the Jimi river basin in Ashanti region of Ghana. Metal concentrations were high in sediments and water. Arsenic averaged 1746.51 mg/kg. Fruits showed extremely elevated levels of Hg and As. Arsenic concentrations in river samples from Tarkwa ranged <1.0-73 ug/L [18]; whereas the determination of As in water bodies at Konongo and its surrounding communities showed significant levels of As [15].

Around the town of Obuasi, high arsenic concentrations have been found in soils close to the mines and treatment works. Some high concentrations have also been reported in river waters close to the mining activity [20]. Despite the presence of high arsenic concentrations in the contaminated soils and in bedrocks close to the mines, Smedley [20] found that many of the groundwaters of the Obuasi area had low concentrations of arsenic with a medium value in borehole waters of just 2 µg/L. Some higher concentrations were observed (up to 64 µg/L), but these were not generally in the vicinity of the mines or related directly to mining activity. Rather, the higher concentrations were found to be present in relatively reducing groundwaters. Oxidizing groundwaters, especially from shallow hand-dug wells, had low As concentrations. This was taken to be due to strong adsorption onto hydrous ferric oxides under the prevailing acidic groundwater conditions, median pH 5.4 in dug wells.

Bowell [12] reported that in mine-contaminated soils of Obuasi, As concentration decreases with increasing depth while in the uncontaminated soils overlying bedrock, As concentration increases down the soil profile with the highest values of about (1025 mg/kg) occurring directly over mineralized bedrock. However, in the soil overlying the unmineralised bedrock, As concentration shows very little variation.

Overall, Norman [22] put 10 % of Ghana's rural boreholes water wells to have As levels greater than WHO guideline value of 10 µg/L. This is due to the upper Birimiam rock, gold–As mineralization, low pH and high total dissolve solids (TDS). Furthermore, there are reports on health studies (e.g. hyperkeratosis and hyperpig-mentation) in some individuals living in Obuasi [23]. Duker*et al*., [24] noted Buruli ulcer (caused by *Mycobacterium ulcerans*) is very common in Amansie West District of Ghana and is the result of As enriched drainages and farmlands.

CONCLUSION

In cognizance of the above, it is apparent that, the As research in the Ghanaian environment focused primarily on surface waters, soils, food crops, fruits and biological samples with limited studies on groundwater, identified as the major source of As poisoning globally. Furthermore the few studies performed in some parts of Ashanti Region were restricted to only few sites with most communities unattended. Unfortunately, gold mining is progressing steadily in the south-western Ashanti Region environment known to have geology rich in arsenopyrite. Yet, the impact of this element in the Ghanaian environment has not received the fullest attention. Humans and animals are exposed to As through drinking, diet and inhalation.

REFERENCES

[1] Kesse, G.O. (1985): *The mineral and rock resources of Ghana*. A.A. Balkema, Rotterdam.

[2] Boroughs, D.L. (1997): *Africa's untapped billions: the new gold rush*. US News and World Report 22:48.

[3] Akabzaa, T., Darimani, A. (2001): *Impact of mining sector investment in Ghana: a study of the Tarkwa Mining Region*. Report to SAPRI.

[4] Griffis, R.J., Barning, K., Agezo, F.L., Akosah, F.K. (2002): *Gold deposits of Ghana*. Minerals Commission of Ghana, Accra.

[5] AngloGold Ashanti. (2004): *AngloGold Ashanti Annual Report*.

[6] Regional Surveys of the World. (2004): *Africa South of the Sahara 2004*.3rd edition. Europa Publications Ltd (Verlag) 978-1-85743-195-7 (ISBN), 97-112.

[7] Quansah, W.T. (2012): District Chief Planning Officer, Amansie Central District Assembly [oral reference].

[8] Bempah, C.K., Ewusi, A., Obiri-Yeboah, S., Asabere, S.A., Mensah, F., Boateng, J., Voigt, H-J. (2013): *Distribution of arsenic and heavy metals from mine tailings dams at Obuasi Municipality of Ghana*. American Journal of Engineering Research, 2 (5), 61-70.

[9] Amonoo-Neizer, E.H., Busari, G.L. (1980): *Arsenic status of Ghana soils near a gold smelter*. Ghana Journal of Science, 20 (1, 2), 57-62.

[10] Amonoo-Neizer, E.H., Nyamah, D., Bakiamoh, S.B. (1996): *Mercury and arsenic pollution in soil and biological samples around the mining towns of Obuasi, Ghana*.Water and Soil Pollution. 91, 363-373.

[11] Amonoo-Neizer, E.H., Amekor, E.M.K. (1993): *Determination of total arsenic in environmental samples from Kumasi and Obuasi, Ghana*. Environmental Health and Perspective, 101(1) 44–49.

[12] Bowell, R.J., Morley, N.H., Din, V.K. (1994): *Arsenic speciation in the pore waters from the Ashanti Mine, Ghana*. Applied Geochemistry, 9, 15-22.

[13] Golow, A.A., Schlueter, A., Amihere-Mensah, S., Granson, H.L.K., Tetteh, M.S. (1996): *Distribution of arsenic and sulphate in the vicinity of Ashanti goldmine at Obuasi, Ghana*. Bulletin of Environmental Contamination and Toxicology, 56: 703-710.

[14] Ahmad, K., Carboo, D. (2000): *Speciation of As (III) and As (V) in some Ghanaian gold tailings by a simple distillation method*. Water, Air Soil Pollution, 122, 317-326.

[15] Boadu, M., Osae, E.K., Gollow, A.A., Serfor-Armah, Y., Nyarko, B.J.B. (2001): *Determination of arsenic in some water bodies, untreated ore and tailing samples at Konongo in the Ashanti region of Ghana and its surrounding towns and villages by instrumental neutron activation analysis*. Journal of Radioanalytical and Nuclear Chemistry, 249 (3), 581-585.

[16] Akabzaa, T.M., Banoeng-Yakubu, B., Seyire, J.S. (2005): *Heavy metal contamination in some mining communities within Jimi river basin in Ashanti Region*. Journal of the Ghana Science Association, 7 no.1.

[17] Asklund, R., Eldvall, B. (2005): *Contamination of water resources in Tarkwa mining area of Ghana*. Department of Engineering Geology, Lund University, Sweden.

[18] Ansong Asante, O., Agusa, T., Kubota, R., Subramania, A., Ansa-Asare, O.D.,Tanbe, S. (2005): *14th symposium on Environmental chemistry, Osaka.*

[19] Amonoo-Neizer, E.H. (1980): *Isoptopically exchangeable phosphate, sulphate, and arsenate in some Ghana soils*. University of Science and Technology, 9 (30), 116-120.

[20] Smedley, P.L., Edmunds, W.M., Pelig-Ba, K.B. (1996): *Mobility of arsenic in groundwater in the Obuasi area of Ghana.* In: Appleton, J.D., Fuge, R., McCall, G.J.H. (Eds.), *Environmental Geochemistry and Health*, Geological Society Special Publication.113. Geological Society, London, pp. 163–181.

[21] Amasa, S.K. (1975): *Arsenic pollution at Obuasi goldmine, town, and surrounding countryside*. Environmental Health and Perspective, 12, 131-135.

[22] Norman, D. I., Miller, G. P., Branvold, L., Thomas, T., Appiah, H., Ayamsegna, J.,Nartey, R. (2006): *Arsenic in Ghana, West Africa, Ground waters*. USGS Workshop on Arsenic in the environment (Abstract)

[23] 23. Akabzaa, T.M. (2000): *Boom and Dislocation*. Third World Network-Africa, pp. 131.

[24] 24. Duker, A.A., Carranza, E.I.M., Hale, M. (2004): *Spatial depency of Buruli ulcer prevalence on arsenic-enriched domains in Amansei West District, Ghana: implications for arsenic meditation in mycobacterium ulcerans infection*. International Journal of Health and Geographics, 3, 19.