Technical note

Incidents of cyanide spillage in Ghana

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Cyanide spills and exposures in the mining industry have occurred in many countries and in recent times there has been extensive publicity, with some moves towards the banning of cyanide in mining. Cyanide spills or accidental release of cyanide-bearing tailings and solutions into the environment, mostly as a result of containment failure, are usually managed by detoxifying the residual cyanide using well known methods before allowing the escape of the sludge. Ghana, a small West African gold mining country, has not been spared these unfortunate incidences. In the last decade and a half, eight incidents of cyanide spills have occurred. The most recent, in October 2001, was at Gold Fields Ghana Ltd in Tarkwa. This paper chronicles the various cyanide spills in Ghana and makes an assessment of the recent spill in Tarkwa. It is noted that the cyanide detoxification process contributed in no small measure to the adverse impact on the environment.

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INTRODUCTION

Reports of cyanide exposure as a result of mining operations are common worldwide. Exposure to cyanide may come from open cyanide solution ponds at mining sites, accidental spills during transport to mine sites or from effluent, or tailings and sludge discharges into the environment, mostly as a result of accidents at the containment facility. Currently there are worldwide campaigns aimed at banning the use of cyanide in the mining industry.[1] This is because although knowledge of cyanide toxicity and treatment as well as its environmental effects has rapidly grown in the past decade, there still exist misconceptions and fears regarding the chemical.

Cyanide has been used for over 100 years to extract gold. The mining industry the world over employs cyanide compounds in ore processing for two main purposes: as leaching agents for precious metals; and as depressants in base metal flotation. Both applications can lead to the presence of cyanide in the effluents, which may then require detoxification to protect the environment. Natural degradation of cyanide in a tailings pond or in the effluent impoundment area is one of the most common current methods of removal used in the mining industry. Cyanide can also be destroyed or detoxified by using alkaline chlorination, the Cyanisorb cyanide recovery process, Inco's SO_2/air process or the peroxide process.

Numerous accidental spills of sodium cyanide or potassium cyanide into rivers and streams have resulted in massive kills of fishes, amphibians, aquatic insects and aquatic vegetation, and these have been well documented.[2,3] In recent times, the transporting of large quantities of cyanide for mining purposes has resulted in major spills in Kyrgyzstan, Papua New Guinea and China. Exposure as a result of cyanide spills at mining sites is also common in spite of improved containment engineering designs and safety standards. Incidents have been recorded in Japan, Canada, Europe and elsewhere.[1] The present paper recounts incidents of cyanide spills in Ghana that occurred between 1989 and 2002. It also assesses the impact of a recent spill at Gold Fields Ghana Ltd, a mine located in the southwestern part of Ghana, West Africa.

GOLD MINING AND CYANIDE SPILLS IN GHANA

Ghana, like many other mining countries, has had its share of cyanide spills in the past one and a half decades. Between 1989 and 2002, Ghana recorded eight accidental cyanide spills. It is worth noting that there is considerable paucity of information in documents detailing the repercussions of the spills in Ghana.

Gold mining has played a central role in the social, political and economic life of Ghana and its people for more than 500 years. Small scale mining, underground mining and surface (open cast) mining have all been practised over the years. The favourable investment climate in Ghana has attracted a number of mining companies in the past 10–15 years. Currently, the majority of the mines in Ghana are surface mines, and are concentrated in the southwestern part of the country (Fig. 1).

The processing techniques in Ghana include heap leach carbon in column (CIC), operated by Gold Fields Ghana Ltd (GFGL); carbon in leach (CIL), as operated at Bogoso Gold Ltd (BGL), Aboso Goldfields Ltd (AGL), and Ashanti Goldfields Bibiani Ltd (AGBL); and biological oxidation (Biox) and CIL as operated at Ashanti Goldfields Corp. (AGC), Obuasi. All these techniques employ cyanide. While the cyanide slurries are allowed to degrade naturally, taking advantage of the climate, most mines employ alkaline chlorination for detoxifying cyanide and occasionally, particularly during emergencies, hydrogen peroxide is also used.

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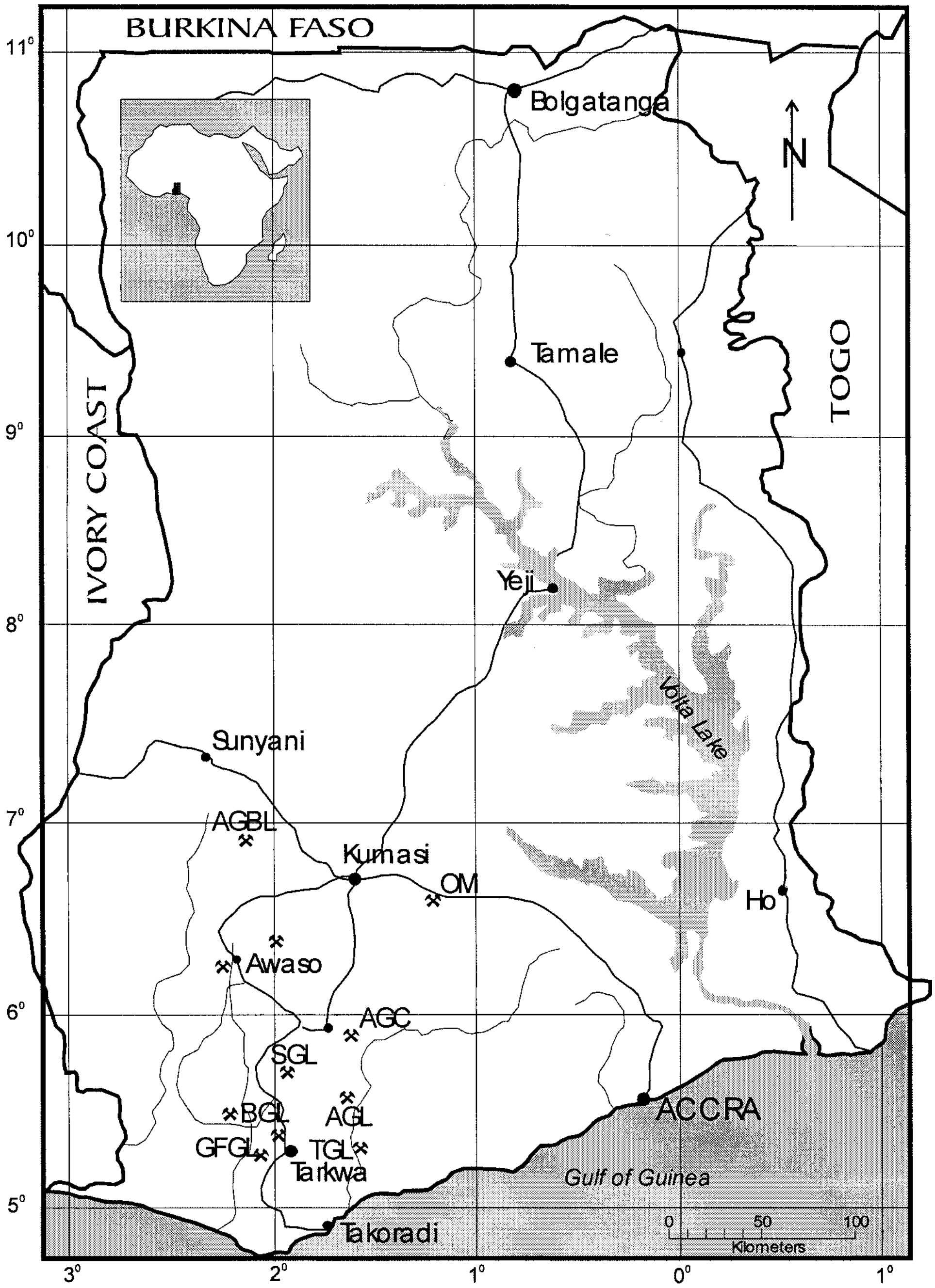

LEGEND

AGBL: Ashanti Goldfields Bibiani Limited
OM: Obenemasi Mine
AGC: Ashanti Goldfields Corporation
SGL: Satellite Goldfields Limited
BGL: Bogoso Gold Limited
AGL: Abosso Goldfields Limited
TGL: Teberebie Goldfields Limited
GFGL: Gold Fields Ghana Limited

1 Locations of gold mines in Ghana

Cyanide spills in Ghana

In 1989 there was a cyanide spillage at the Obenemase Mine (OM) near Konongo after a heavy downpour. The ponds merged and overflowed the embankment, draining into the environment. The spillage contaminated a tributary of the Owerri River.

In 1991 there was a cyanide spillage at Billiton Bogoso Gold (now BGL). No further information on this accident is available.

In 1994 a truck conveying sodium cyanide to Billiton Bogoso Gold was involved in an accident at Samahu near Tarkwa, resulting in cyanide spill into the environment and causing the death of frogs in a nearby wetland.

In 1996 after a heavy downpour, a design flaw in the plastic lining of a solution pond caused a berm failure at Teberebie Goldfields Ltd (TGL). The entire amount of cyanide solution in the pond was released into the Angonaben stream, a main tributary of the Bonsa River. There was loss of aquatic life.

Two incidents occurred in 1999. The first was a tailings dam pipeline burst at Bibiani, which caused pollution in the Tano River. This accident was detected in the very early stage and was contained.

However, death of fish was reported. The second incident was pollution of the river Nyam at Anwona-Sansu by Dokyiwa tailings dam at Ashanti Goldfields Ltd, Obuasi that affected vegetation.

More recently, in 2001, there were two cyanide spillages in two weeks, involving GFGL, Tarkwa in the Wassa West District and Satellite Goldfields Ltd (SGL), at Akyempim in the Mpohor Wassa East District, both in the Western Region. In the case of the SGL accident, a crack formed in the **T** piece Yelomine pipe carrying barren solution, apparently due to stress and a possible manufacturing defect in the pipe. Even though there was no significant impact on the nearby Kubekro stream, the people in the Kubekro village were warned not to use the stream until it was declared safe. The spillage of cyanide, which occurred at GFGL, Tarkwa, received widespread media reportage, and for the first time, the Government of Ghana set up an investigative committee to report on the matter.

Cyanide spill at GFGL

On 16 October 2001, as a result of a heavy rainfall a small earth slide occurred on the heap leach pad. The moving soil pushed a pipe carrying cyanide solution from the ponds to the pads and broke it at the coupling joint. The solution escaped from the pipe and ran down the access ramp into the stormwater ditch from where it escaped into the nearby Sumang stream through a culvert. The spillage was detected at about 3·45am by the company's personnel working on a conveyor breakdown. In their estimation the spillage must have taken place between 1·30 and 1·45am.

Rainfall data revealed that on 15 October 2001 (the day before the incident), 12·5 mm of rain was recorded between 3·10 and 3·25pm, and thereafter showers of rain (0·1 mm) were noted untill 10·25pm the same day. On the day of the incident no further rain was recorded. The earlier rain could have soaked the heap leach pad, creating instability, which precipitated the slide.

The company had constructed a culvert (contrary to design specifications) from the stormwater ditch, adjacent to the heap leach pad, into the Sumang drainage area, and this provided an exit for the cyanide solution from the containment area. The bridging of the protective embankment around the leach pad facility with agglomerated ore, to enable conveyor repair work, also contributed to the escape of the solution to the containment area.

From the approximately 2 h between leakage and detection, GFGL estimated that the maximum quantity of solution leakage was 900 m^3 of which 650 m^3 escaped into the environment. Some of the remainder infiltrated the porous heap leach surface and part was trapped by spill containment measures.

Detoxification measures were undertaken, including the use of hydrogen peroxide and calcium hypochlorite. Four 55 gallon drums of 60 vol.-% hydrogen peroxide and three 40 kg containers of powdered 100% calcium hypochlorite were used. Four tanker loads of water were then used to flush the detoxification agents down the drain into the Sumang stream. Two 40 kg containers of powdered 100% calcium hypochlorite were used to detoxify the leakage that ponded inside the controlled area once leakage to the environment had been stopped. The liquid detoxified with the two containers of calcium hypochlorite was pumped directly back into the lined area of the heap leach pad.

As part of the emergency response procedure, company personnel were immediately despatched to communities downstream to alert residents, and to test the water quality. An alternate source of water supply was provided. Bad access road to the communities delayed the transmission of information on the incident to most settlers.

Impact of cyanide spill at GFGL

Company personnel found a total of approximately 50 dead fish of lengths between 50 and 100 mm within 200 m of the site of the leakage and detoxification. Some villagers were reported to have caught distressed fish, which they used for food.

The main complaints from the communities where people had eaten distressed fish, or had used the polluted water for bathing, drinking and preparing of food, included diarrhoea, abdominal pains, blurred vision, eye itchiness, skin rashes, skin itchiness, skin blisters, skin peeling, bloody urine and burning sensation in the legs. These complaints were alleged to have started at the time of the spillage and persisted among most communities even after five months.

It must be noted that not all the symptoms reported by the communities were attributable to the cyanide spill. Some people took undue advantage of the incident and, with the hope of making compensation claims, complained of illnesses that existed before the spill. Most of the eye problems were cases of onchocerciasis, while some complaints of bloody urine were due to schistosomiasis. In some communities, the diarrhoea and abdominal pains were also a result of unsanitary conditions that led to high coliform levels in the water they consumed.

Generally the community perception was of a rather poor relationship with GFGL – borne out by the lack of progress towards physical developments and improvements in social amenities in these communities despite their closeness to the 'pot of gold'.

In general, the assessment mission on the accident concluded that the company took reasonable steps to control the emergency and to minimise the impact. The impact on flora, fauna and on humans was very much similar to those reported elsewhere.

Impact of detoxification measures at GFGL

As part of the emergency response process, soon after the spill at GFGL was detected attempts were made to detoxify the cyanide solution that escaped into the environment. Unfortunately, the detoxification procedure appeared to have been performed as a panic reaction, and the detoxicants used were not only in excess, but chased after the already diluted cyanide plume. Results of the stream water analysis at the community sampling points soon after the spill revealed that cyanide levels were below lethal dose for fish. Neither the exact time of the spillage nor the flowrate of the solution excursion was known. Further, the incident occurred at night, at a time when no one was around. Therefore, determining the correct dose of detoxificants posed problems. The amount of peroxide, and particularly hypochlorite, used turned out to be far in excess of what was required.

From a simple calculation based on the assumption that all the 650 m^3 cyanide solution that escaped in the environment was impounded (i.e. within a losed containment) to be detoxified, then the 220 gallons (about 1000 L) of 60 vol.-% hydrogen peroxide added was twice the amount that would be required to completely detoxify 650 m^3 of 180 ppm cyanide solution.

The 120 kg calcium hypochlorite [$Ca(OCl)_2$)] subsequently added was therefore not really necessary for the detoxification, and was unfortunately flushed down the reaches of the Sumang stream with four tanker loads of water. This extra hypochlorite may have caused the fish kills in the stream, skin irritation upon contact, vomiting and diarrhoea on ingestion and abdominal pain. It is known that detoxicants such as hypochlorite and peroxide can lead to clinical manifestations such as gastrointestinal irritations with nausea, vomiting and diarrhoea, and irritation of the eyes, which were reported by the affected communities.[4]

OBSERVATIONS

The accident at GFGL exposed the fact that there was little public awareness in the local population of the environmental and safety risks that could occur at mining sites. Some settlers did not recognise that distressed fish in streams into which effluents are discharged could signal pollution; therefore, some distressed fish caught were unfortunately used for food. Poor access roads to the communities also prevented the timely flow of vital information.

The leakage of the cyanide solution into the environment at GFGL was a result of an unauthorised construction of a culvert and the bridging of the protective embankment of the containment area with agglomerated ore to enable conveyor repair work. This could have been prevented if regulatory authorities had been more critical in their inspections, since the culvert in question had been in existence for several months before the spill.

In all cases of spills attempts are made to put emergency response procedures in place. Most often the line of action includes the use of detoxicants. Some cyanide detoxicants introduce contaminants into water bodies, and if not carefully selected, taking into account the soil chemistry along water routes, and dispensed in proportion to the amount of cyanides being detoxified, can result in major impacts.

Observations at mine sites indicate that even the routine detoxification of cyanide effluents using alkaline chlorination before discharge is not effective in safeguarding the environment. Visual observations of flora along discharge routes in the vicinity of cyanide containment facilities in Ghana indicate that products resulting from the detoxification processes do have adverse effect on the ecology. For example, the green vegetation in the areas concerned turns brownish, and some flora species disappear.

During emergencies, detoxification is usually a panic reaction and, in view of the inaccurate estimation of the amount of cyanide solution that has escaped into the environment, can lead to disproportionate quantities of detoxifying agents being used. In most cases the quantities of detoxifying agents used are excessive, as was seen at GFGL, and this contributes to the impacts that were reported.

RECOMMENDATIONS

To assist mining companies and regulatory authorities in the control of cyanide spills and its impacts, the following measures are recommended:

1. To improve public awareness of environmental safety and risks of mining operations, regulatory authorities should mount programmes to bridge the knowledge gap between the mining companies and the local communities. Community relations and focused support for the communities by mining companies is also vital.
2. Inspections conducted at mine sites by regulatory bodies often become routine, and critical assessments are not carried out. Critical inspection of containment sites, together with improved designs, would go a long way to reduce spills from containment areas.
3. Detoxification by alkaline chlorination is known to introduce into the environment compounds toxic to aquatic life, and should not be the first option, unless there is adequate information on the soil types at the spill sites to indicate that the detoxification would not compound the impact.
4. Detoxification using hydrogen peroxide appears to be the most environmentally friendly method among the current known technologies. Unlike other cyanide destruction methods, oxidation of cyanide with hydrogen peroxide is a fast, one-step reaction, neither forming toxic intermediates nor substantially increasing the total dissolved solids concentration. Excess hydrogen peroxide decomposes to water and oxygen.[5] Though more expensive, use of this method exclusively for both routine and emergency detoxification would reduce the impact of cyanide in the vicinity of mining sites.

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