Measuring cyanide

Benedikt Kirchgaessler* and **Christine Blackmore FIMMM** discuss a novel approach to the measurement of cyanide concentration.

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Cyanide was first used in mining in New Zealand in 1887. Since then, cyanide, especially sodium cyanide (NaCN), has played a key role in extracting gold and other metals globally. It is estimated that up to 90% of the world's gold production involves the use of cyanide.

While highly valuable in the gold processing chain, the material can be difficult to manage and has been linked to health risks. But a smart monitoring device, CyanoSmart, developed by CyanoGuard AG, Sweden, allows mines to digitally monitor their cynanide consumption in real-time, and optimise their process, increase gold recovery rates and reduce processing costs. The technology has been tested at a mine in Mexico and, so far, the results have been promising.

Effects on health

Fish are the most cyanide-sensitive group of aquatic organisms. Birds tend to be slightly more resistant to contact with free cyanide, however, toxicity in mammals is relatively common, mostly due to the amount of naturally occurring, cyanogenic forage plants. But there are a number of factors limiting widespread cyanide toxicity through the environment. For example, the chemical has a low persistence in the environment and is not bio-accumulated or stored in any species, there are no reported biomagnifications of it in the food chain, repeated sub-lethal doses can lead to adverse affects, and many species can tolerate cyanide on substantial but sub-lethal dose over long periods of time.

Cyanide is readily absorbed in humans through inhalation, ingestion or skin contact, and is quickly distributed throughout the body via the bloodstream. The chemical is also a potent asphyxiant, hence, careful management of cyanide in any industrial process is required.

Regulation changes

A number of high-profile accidental releases have resulted from mining operations using cyanide. These include the Baia Mare, Romania, cyanide spill in 2000, when an estimated 100 tonnes (t) of the chemical and heavy metals were released into the Lapus River, which flows into other streams that enters the Danube.

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Above: Aerial drone view of cyanide pollution from an open pit gold mine.

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This was a result of intense rainfall and snowmelt, which led to high water levels in the tailings management facility – a dam overflowed and a 25m stretch of dam, 2.5m deep, washed away.

This accident acted as a catalyst for a comprehensive review of best practice in cyanide management, resulting in the publication of a cyanide code by the International Cyanide Management Institute (ICMI). Every mining operation using the chemical is encouraged to use the code as guidance to prepare a robust cyanide management plan. By becoming a signatory to the code, a company is effectively guaranteeing that best practice with the chemical will be deployed.

Cyanide management helps ensure the process is well managed and optimised. Too little cyanide will limit the amount of gold that can be recovered, too much often results in the disposal or destruction of cyanide at the tailings facility.

The price of cyanide, and especially sodium cyanide (NaCN) pellets – the form of cyanide used most frequently at mining operations – varies between suppliers. However, the current cost of NaCN per tonne is approaching US$2,500 and hence, overuse of cyanide when it produces no additional metal recovery should be avoided.

Material wastage

Every year, the gold mining industry loses about US$5bln in recoverable gold due to inefficient process monitoring and control. With cyanide levels being the crucial parameter for the gold extraction process and mines reporting it as one of the main gold processing cost drivers, cyanide costs alone make up more than 51% of the total processing costs, according to a 2018 technical report for Los Filos Gold Mine Guerrero State, Mexico, by Leagold Mining Corporation.

Commonly, gold mines use silver nitrate titration to determine free cyanide. First described by German Chemist Justus Liebig in 1851, a silver nitrate solution is added to the cyanide-containing sample, where free cyanide complexes with silver. Excess silver ions react with an indicator that changes colour once in contacts silver ions.

While the limitations of this method have been studied and publicised, mines widely rely on the titration procedure due to a lack of available and viable alternatives. The measurements are hard to reproduce as the result relies on the colour perception of the operator.

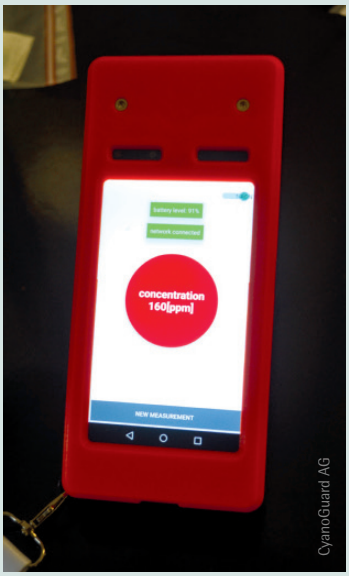
The data often falsely over or underestimates the cyanide concentration due to substances interfering with the method. As a result, mines are left with flawed data and are unable to control the cyanide levels in their process.

Also, the titration method cannot be performed easily in the field, meaning that samples need to be taken to a laboratory before analysis can begin. Often there is a minimum 24-hour time lag between taking the sample and knowing the cyanide concentration, making process improvements difficult.

L–R:

A reading from CyanoSmart.

The CyanoSmart testing device.



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Inaccurate cyanide readings create two substantial problems for the operator. If cyanide levels are over-estimated, the operator should reduce them back to the set-point. A cyanide deficient process fails to extract otherwise recoverable gold, and gold is lost to tailings. If they are underestimated, the operator may increase cyanide use, and if this is excessive it may result in more reagents needed to remediate higher cyanide levels. Mines need simple, dependable and robust solutions with low operator variability and robustness against common interferences.

Keeping tabs

A new technology for cyanide monitoring in gold mines has been developed, enabling mines to optimise their process digitally, increase gold recovery rates and reduce processing costs.

The technology allows mines to digitally monitor this parameter in real-time with a robust setup to reduce costs and increase process efficiency.

CyanoSmart is a handheld device that enables users to determine the cyanide concentration instantaneously on the spot, without having to use expensive equipment, or have expert knowledge. The procedure takes less than 60 seconds and the results are displayed on the touchscreen. Simultaneously, results are available in real-time through an online interface so that process engineers can regulate and optimise cyanide addition within the process.

The device consists of a handheld analyser connected to an online monitoring platform and single-use test cartridges. The cartridges contain a patented cyanide-sensing molecule based on a modified vitamin B12 molecule. The non-hazardous assay was developed to overcome the limitations of traditional cyanide analysis.

It is highly selective and resistant against substances, which interfere with traditional methods, and are common in mining samples like copper, thiocyanate, thiosulphate, zinc or chloride.

Depending on the concentration of cyanide in the sample measured, the molecule inside the cartridge changes colour. Algorithms analyse the change in colour and instantaneously provide a free cyanide concentration reading.

The device also obtains the location of each measurement taken via GPS, and submits the data in real-time to the online cloud platform. The data can be visualised, for example on a map, analysed and exported for further data processing in real-time.

With a method of detection more resilient against interference, the technology provides the operator with a reliable result even with changing ore composition.

Below: Data read from the CyanoSmart device.

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Above: On-site at Mexico performing the cyanide test.

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The standardised procedure reduces operator error and variability. Having dependable and accurate results allows mines to avoid excessive cyanide consumption and the loss of recoverable gold.

With the time to get a result substantially reduced from hours with traditional laboratory methods to seconds, mines can adjust their cyanide levels faster and reduce NaCN consumption. As an example, a gold mine in Mexico has throughput of 5,000 bank cubic metres of cyanide solution per hour.

A CyanoSmart device was used to test the level of cyanide on site. Initial data suggested an average optimisation value of 20 milligrams per litre reduced the NaCN consumption by 100kg/h. But with bulk purchase, the cost of about US$2,500/t of sodium cyanide, the mine could save more than US$150,000 per month of that chemical.

An effective solution

There are tangible, economic and technical benefits for efficient cyanide control that maximise resources and minimise environmental impacts of mining operations. Disastrous cyanide spillages require effective real-time data regarding cyanide concentration. The use of devices such as the CyanoSmart have the potential to generate such data.

However, perhaps the largest benefit of this device is in improving process control. Levels of cyanide can be monitored in something approaching real-time to ensure the cyanide concentration is maintained at optimum levels, giving the potential for cost savings by reducing the amount of superfluous cyanide and increasing resource efficiency.