Abandoned Mine Water Treatment

A Mine With a Rich History

The Wheal Jane mine, an abandoned mine located in southwest Cornwall, UK, was worked for tin, copper, silver, zinc and arsenic starting in the 18th century. Mineral extraction ended and the mine was formally abandoned in September 1991, following the collapse of tin prices. In the 18th and 19th centuries, Cornwall was one of the richest mining economies in the world and Wheal Jane had long been a byword for the most modern in mining techniques and infrastructure. In 1992, however, Wheal Jane had become synonymous with mine pollution.

Mine Water Treatment Plant

Shortly after the mine was closed, pumps were stopped, allowing the mine to flood. In 1992, over 10 million gallons of polluted water containing iron and other metals was released into Restronguet Creek, Carnon River and Falmouth Bay due to failure of a plug in the underground Nangiles Adit.

During 1992-1993, the Environment Agency progressively upgraded an emergency treatment system, allowing the Agency time to undertake studies and assess long-term treatment options. As a result, a mine water treatment plant was designed and constructed to meet the stringent discharge limits set by the Environment Agency for discharge to the local water course.

Now, 10 years later, the UK Coal Authority oversees the site, and Veolia Water Solutions & Technologies operates, maintains and manages the mine water treatment plant for the Authority.

Sole Source Responsibility

The flow from the mine varies seasonally, typically peaking in excess of 330 L/s during the winter. To accommodate this range, the plant, which incorporates a high density sludge process, includes two identical treatment streams, each with a rated capacity of 230 L/s. Each stream consists of a Stage I pre-reaction chamber, a Stage II reaction chamber and two lamella clarifiers.

Veolia is responsible for ensuring that more than 500 million liters of contaminated mine water flowing from the old tin mine every month is treated to remove iron, arsenic and other metals. To improve Wheal Jane operations, Veolia Water is currently engaged in a program to reduce lime reagent usage which will also reduce the carbon footprint. Operations by Veolia Water provide the Coal Authority with less operational risk, plus direct access to proven technology operated by dedicated specialists.

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Laboratory-Scale Testing For Improving Tailings Treatment Effluent

Degradation of Cyanide, Biologically

Typically, mines use different chemical options such as sodium hypochlorite (NaOCl) for achieving an oxidation reaction to destroy cyanide in tailings effluent. But often there are concerns with potential chloride buildup over time as well as other concerns related to the use of NaOCl and other chemical oxidants.

A three-month lab-scale study on tailings water (supernate) demonstrated that cyanide and thiocyanate could be significantly degraded biologically by using the AnoxKaldnes® Moving Bed Biofilm Reactor (MBBR) treatment process. The technology is a high-rate, small footprint process based on the biofilm principle and uses plastic media retained in aeration basins to increase capacity of conventional activated sludge treatment. Effective biomass within the reactor augments growth on the media.

During the lab-scale study, wastewater from a mine site, ranging in concentrations from 2.5 - 3.6 mg/L of cyanide and 0.4 to 4.6 mg/L of thiocyanate, was treated. At a hydraulic residence time (HRT) of 3-3.5 days, effluent thiocyanate was <0.005-0.015 mg/L and an effluent free cyanide below 0.01 mg/L was obtained. The data was measured using an in-house direct colorimetric method (see Graph 1).

The tests also showed that released ammonium generated during cyanide and thiocyanate removal can be nitrified. Within the final weeks of the study, most of the cyanide removal and nitrification took place in the first stage reactor, showing that the process can be potentially operated at shorter HRTs.

**Nitrification & Denitrification**

In a separate study, a synthetic wastewater was composed to simulate the wastewater and low temperature conditions (2 to 10 °C) of operation from a customer’s mine. The wastewater was treated in laboratory model MBBRs for nitrification and denitrification (see Graph 2).

The MBBR process produced effluent discharge quality of approximately 3-4 mg/L NOx-N and below 20 mg/L of BOD5 at the design temperature (4°C), provided that the denitrification was performed in two stages. With one-stage denitrification, the study indicated that effluent NOx-N concentrations of 5-6 mg/L can be expected. At temperatures below 4°C (i.e. 2°C), effluent NOx-N, can be expected to be a little higher.

**Sulfate Reduction With Nano-Filtration**

Veolia Water Solutions & Technologies recently conducted benchtop testing to investigate the application of Nano-filtration (NF) for reducing sulfate concentration in water from a tailings treatment facility. In the study, NF was followed by the precipitation of calcium sulfate from the NF reject stream.

The use of NF membranes generates a reject solution with a high concentration of sulfate ions. The subsequent addition of calcium ions causes the solution to become supersaturated with respect to calcium sulfate, resulting in the precipitation of calcium sulfate (gypsum).

The basic objective was to create the calcium sulfate reaction, flocculate and settle the precipitate, and end up with a supernate that is lower in sulfate. The ultimate goal was to achieve a minimum 10X reject concentration in a double pass mode, which can be attained by operating between 75% and 80% recovery, in a first pass and then a reject recovery pass. The test was successful, removing approximately 70% of the sulfate.

Investment risk can be reduced by having Veolia Water Solutions & Technologies define process chemistry and unit operations in the laboratory, and by performing confirmation testing in the field. Laboratory-scale testing is the first step in providing the conceptual and detailed designs for improvements to treatment systems.

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Dust Control Strategies
Improve Safety and Reduce Maintenance

Effective mine tailings dust, conveyer, and haul road dust control helps ensure compliance, lower maintenance costs and safe working conditions. Characterizing the various dust control agents can provide mine operators additional insight for effectively reducing dust.

**Roads**

The objective of chemical agents is to control fugitive dust from the surface mine and plant haul roads due to high truck traffic. The three most important chemical bases used as action mechanisms for road dust control agents include salts, lignin and surfactant products.

Calcium and magnesium brines absorb moisture from the environment to maintain the water and decrease evaporation. The fine particles treated with calcium chloride are joined and agglomerated with other fine particles, adding a higher density and stability on the road surface.

Lignin derivative products work to join very fine and small particles together with larger sized particles, creating larger particles to form a stable polymeric base to control dust generation. Surfactant-based products are capable of reducing the surface tension of water wettability, enabling better wetting of the fine particles, saving water and providing humidity control.

**Transfer points**

Dust control agents are used at the transfer points of conveyor belts. Chemical bases include surfactants, binders (and a mix of the two), and foamers. Surfactant products decrease the size of drops to permit better contact between small dust particles and solution drops. Binders stick the particles together, increasing their size so they cannot become airborne. The accepted mechanism for foamers indicates that, on contact, a bubble is produced that collapses over the particle, encapsulating it in a liquid matrix.

**Storage Piles**

This application prevents carryover of fine particles moved by the wind. There are different control agents for stationary and mobile piles (such as railway transport). Chemical bases include polyacrylamide polymers, asphalt emulsions, crust latex and foamers. Products for immobile piles create a film, or crust, over the surface. For mobile piles, polymers are added in the solution, which are absorbed in the particles and then assemble into bigger particles resistant to wind.

Veolia Water’s Hydrex™ Chemicals can be applied to road, transfer points and storage piles for dust control solutions. Enhancing dust control at a mine site can prevent wind erosion, the loss of valuable materials, air dust pollution and increase safety around stock pile areas and roads.

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Bringing a Vital Resource to the World’s Arid Mining Regions

Desalinated Water Supply For Remote Mines

Seawater desalination is becoming increasingly necessary to support mine development in arid regions such as northern Chile, southern Peru, southern Africa, western Australia and other regions that are rich in mineral deposits but poor in water resources. Advancements in technologies have made seawater desalination a viable solution for water supply to many of these remote mining locations.

Conveying seawater to mine site locations raises many challenges. The conveyance of desalinated seawater from seacoasts to mining sites typically covers long distances and often significant changes in elevation. High-pressure pipelines and pumping stations are necessary, which represents significant investments for mining companies. There are many aspects that must be considered for the design, engineering, and delivery of a large-scale water supply project.

Challenging Project Execution

A major aspect to successful desalinated seawater conveyance projects is the handling of complex logistics necessary for project execution in challenging geographical settings. For example, SADE, a Veolia Water company, recently completed participation in a major project to supply fresh water to Nouakchott, the capital of Mauritania in west Africa, from the Senegal River located nearly 200 kilometers to the South.

SADE laid nearly 170 km of 1,400 mm ductile cast iron underground pipe and associated installations (including more than 450 drainage structures, plus air valves, cutoff valves and surge tanks) between Beni-Nadji and Nouakchott. The company also laid two 1,100 mm cast iron, PUX lined self-anchored pipes in parallel to a 6 km embankment that was built alongside the Senegal River to allow for the crossing of a marshy area.

An essential requirement for this project was SADE’s ability to handle the distance and natural harsh environment, plus the shear scale of the project. During the peak activity period, there were nearly 650 people working on the project that were organized in four teams with access to separate resources. The project was tightly organized to efficiently manage the supply chain for the 120,000 tons of pipe required. Deployment of other special logistical resources included construction and maintenance of 32 km of access roads in a semi-desert area and 1,200,000 m³ of earthworks for trenches.

Meeting the Water Demand

The increase for worldwide mineral extraction and processing is raising the demand for water. Existing mining operations are expanding operations and new projects are developing. This increase will lead to a need for more desalination plants and conveyance systems. We have the experience and proven technologies to meet the economical, environmental, and operational requirements to bring the supply of desalinated seawater to remote mines.

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