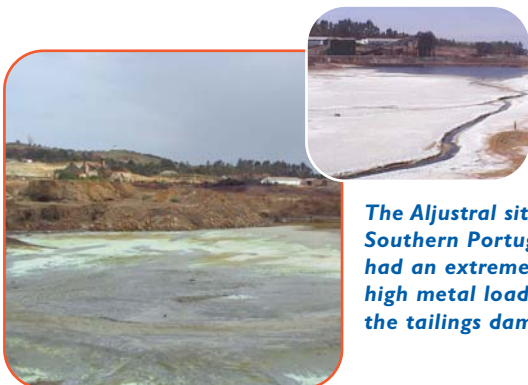


AN APPLICATION OF  
VIROMINE™ TECHNOLOGY

CASE STUDY: ALJUSTREL,  
ACID ROCK DRAINAGE TREATMENT,  
PORTUGAL

*“The water in the tailings dam was characterised as a sulphuric acid solution of iron, aluminium and heavy metals and had a total dissolved metal load in excess of 6,800 mg/L... Following treatment using ViroMine™ Technology, contaminant concentrations in the treated water from the Aqua Forte tailings dam at Aljustrel were well below the targets set by Portuguese Water Discharge Limits.”*



*The Aljustrel site in Southern Portugal had an extremely high metal load in the tailings dam.*

## &gt;&gt;&gt; CASE STUDY: ALJUSTREL - PORTUGAL

**PROBLEM**

The contaminated water body known as “Aqua Forte” at EXMIN’s Aljustrel site in Southern Portugal contained very high concentrations of heavy metals and was highly acidic. The water in the tailings dam was characterised as a sulphuric acid solution of iron, aluminium and heavy metals and had a total dissolved metal load in excess of 6,800 mg/L. This equates to approximately 170 tonnes of dissolved metals in the 25 ML tailings dam, and in summer evaporative water loss often raised the metal concentrations still further.



**Left: The tailings dam that was treated. Right: Water flowing into the dam contained very high heavy metal loads, leaving deposits like these.**

**VIROTEC TOTAL SOLUTION**

The Virotec total solution proved to be innovative, efficient, effective and immediately applicable to treatment at the Aljustrel site.

Due to the extremely high metal load of the Aqua Forte ARD water it was apparent that more than one ViroMine™ Technology reagent would be necessary to achieve the required target concentrations for metals to allow discharge to occur. Extensive testing of a range of treatment methodologies indicated that a three-stage treatment process utilising ViroMine™ Technology Acid B Extra™, Acid B™ and Neutra B™ reagents gave the best results.

The ViroMine™ Technology reagents used in this treatment were custom designed to neutralise acidity in the water and bind metals in non-bioavailable, chemically inert forms without producing the large volumes of unstable sludge typically associated with lime-based treatments. Equally importantly for effective treatment, the reagents were designed to provide a finely adjusted balance between the rate of metal binding and the rate of pH adjustment.

ViroMine™ Technology converted the hazardous water into a reservoir of clean water by simultaneously extracting the contaminants, and creating and maintaining an isolating blanket over the tailings deposit. This prevented the escape of contaminated pore water interfering with the treatment of the surface water.

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*The mine site is close to the township of Aljustrel which dates back to Roman times. Indeed, some of the acid rock drainage generated in the area originates from mining activity conducted by the Romans over 2,000 years ago.*

The Virotec solution components included design, engineering, application and ongoing monitoring. Application of the Virotec solution resulted in 25 megalitres of treated water being released into the environment with a quality that exceeded both the local Portuguese discharge limits as well as the more stringent ANZECC water quality guidelines for heavy metals.

#### BACKGROUND

Virotec International in a joint venture with Portuguese company TerraPlus, with whom Virotec has a working agreement in Portugal, was approached by the Portuguese government department known as “EXMIN”, to carry out treatment on contaminated water in order to assist EXMIN in their efforts to rehabilitate mining sites.

The Aljustrel site is in Southern Portugal on the Iberian Pyrite Belt and is one of several places across the southern Iberian peninsular where the copper rich seam of mineral comes to the surface. The Iberian Pyrite Belt is one of the world’s largest volcanic massive sulphide zones, home to 60 mines with several deposits over 100 M tonnes, and has been in production for over 2,000 years. Aljustrel was a mining centre as far back as Roman times.

The Portuguese government first granted a concession to establish a copper pyrites mine on the Aljustrel site in 1847. The mine, owned by the government after WWII, was in continuous production until operations were suspended in 1993. In 2001 a private firm purchased the government’s interest in the operating company.

A by-product of the mining operation is waste rock that has a high sulphide mineral content and is capable of generating very large quantities of acid and metal-contaminated water. With a 2,000 year history of mining in the region the site has many problems with acid mine drainage.

ViroMine™ Technology has many advantages over other technologies, especially in soil/rock amendment for the revegetation of sulphidic waste rock dumps. The non-dispersive, sedimentary nature

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***The water in the tailings dam had a total dissolved metal load greater than 6,800 mg/L.***

of exhausted ViroMine™ Technology reagents is a most desirable feature compared to the highly dispersed sludge that commonly remains after alkali treatment such as addition of lime.

Furthermore, the sediment produced by ViroMine™ Technology reagents can be added to soil or waste rock and will support plant growth and hold most of the bound metals sufficiently tightly so that they cannot be taken up by the plants or released in leachate. In fact, most vegetables grown on mine tailings treated with ViroMine™ Technology reagents comply with all standards for human consumption. As demonstrated in many field trials, ViroMine™ Technology reagents blended with rock or soil will sustain strong plant growth without the need to place additional topsoil.

The used ViroMine™ Technology reagents remaining after water treatment can have a secondary usage as a soil amendment media, adding significantly to the value of the product.

## TREATMENT METHODS

### *Reagent Selection*

Aqua Forte water is highly buffered at below a pH of 2.5 due to the stored acidity associated with the very high Fe and Al content. For this reason the ViroMine™ Technology treatment developed for the site comprised a three-stage chemical addition using proprietary reagents.



***The total dissolved metal load equated to approximately 170 tonnes of dissolved metals in the 25 ML tailings dam.***

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The Virotec treatment ensures that every job has a custom-designed treatment solution that will meet customer requirements in the most cost-effective manner. The treatment regime for the Aqua Forte Tailings Dam at Aljustrel utilised three specific ViroMine™ Technology reagents in three separate stages to treat the highly contaminated water.

> **Stage 1 – ViroMine™ Technology Acid B Extra™ Reagent Treatment**

Acid B Extra™ reagent provides a very high alkalinity to react with strong acid but avoids caustic shock. It also removes As during Stage 1 as well as most of the Al and Fe.

> **Stage 2 – ViroMine™ Technology Acid B™ Reagent Treatment**

During Stage 2, Acid B™ reagent binds with Cr, Pb, Cu and most of the Zn. It also reacts with any Al and Fe remaining after Stage 1 treatment. The alkalinity provided by the Acid B™ reagent optimises the reactions in the pH range 3.0-5.0.

> **Stage 3 – ViroMine™ Technology Neutra B™ Reagent Treatment**

Neutra B™ reagent acted as a finishing reagent that was optimised for the pH range 5.0-8.0. In this application the Neutra B™ reagent binds with Co, Ni, Cd, Mn and any Zn remaining after Stage 2 treatment.

The staged treatment is required so that acidity may be treated without overdosing with alkali and thus producing potentially soluble metal hydroxides.

The staged treatment and maintaining a balance between pH adjustment and metal binding are key criteria for Virotec technology treatments. They allow the metal binding reactions to occur in the optimum pH range for each metal component in the water.

**Site Treatment**

Treatment at the site was conducted in three successive phases. At the completion of each phase the treatment was scaled up with the third and final phase seeing the discharge of clean, treated water into the local environment as detailed overleaf.

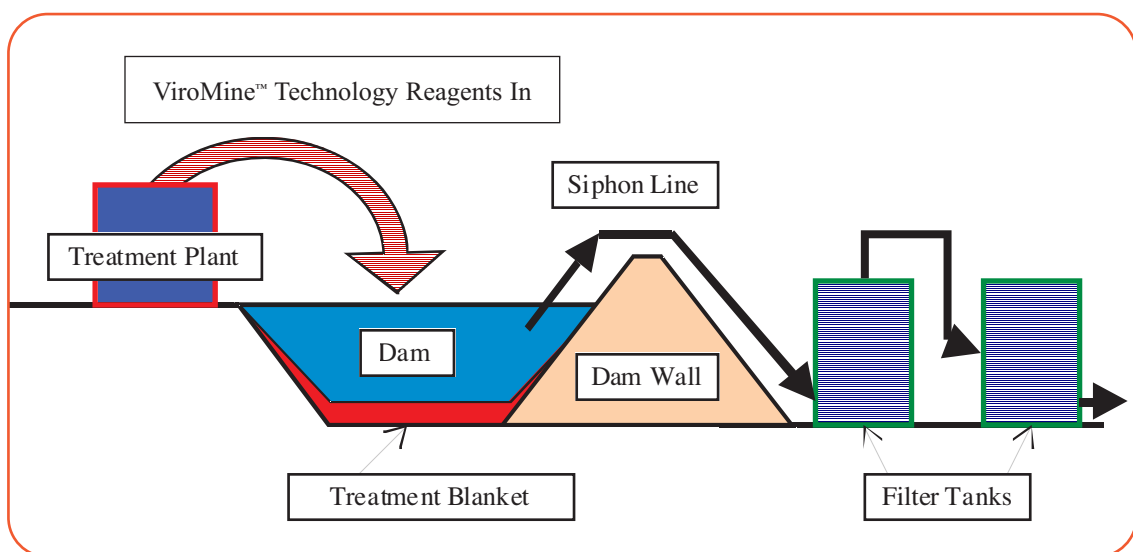


**The different ViroMine™ Technology reagents were applied in slurry form.**

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> **Phase 1 – Trial Treatment**

Several bulk trials (1000L) were conducted over a week long period to validate the laboratory tests and provide information on the behaviour of the sediments already in the dam and their possible influence on the water treatment. Bulk trials at the site established the reaction kinetics for the three selected ViroMine™ Technology reagents and fine-tuned the reagent addition quantities.



FLOW DIAGRAM OF TREATMENT PROCESS

> **Phase 2 – Small-scale Treatment**

A small-scale IML pond of Aqua Forte water was then treated to achieve the target concentrations for metals and pH via the sequential application of the three selected ViroMine™ Technology reagents.

> **Phase 3 – Full-scale Treatment**

The large-scale treatment program for the 25ML water body was carried out by the sequential staged addition of three selected ViroMine™ Technology reagents. Progress of the treatment was monitored using pH as a primary indicator and metal concentrations were determined at the end of each stage. At the end of the Stage 3 of the sequential treatment, having reached the target concentrations for metals, the treated water was discharged into the local waterways.

The use of ViroMine™ Technology reagent slurries ensured that there was an even coverage. The treatment produced an extremely thin and dense sediment. This sediment subsequently acted as a passive barrier for treatment of further ingress of acidic metal-rich pore waters from bottom sediments.

The *in-situ* treatment method used involved no expensive capital infrastructure and a simple reagent application procedure.

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**RESULTS**

Following treatment using ViroMine™ Technology, the treated water from the Aqua Forte tailings dam was well below the target set by Portuguese Water Discharge Limits and even met the more stringent ANZECC metal concentration standards for the protection of aquatic ecosystems (about 100 times cleaner than drinking water). As a result, about 25 million litres of water were released into the local river system.

*Table: Heavy metal and acidity levels before and after treatment with ViroMine™ Technology.*

	Before ViroMine™ Technology Treatment	After ViroMine™ Technology Treatment	Portuguese Water Discharge Limits	ANZECC Guidelines for the Protection of Aquatic Ecosystems
pH	2.3	8.5	6 - 9	6.5 - 9
Aluminium (mg/L)	977	0.012	10	0.1
Arsenic (mg/L)	10.7	0.001	1	0.05
Cadmium (mg/L)	1.91	0.001	0.2	0.002
Cobalt (mg/L)	1.572	< 0.001	N/A	N/A
Chromium (mg/L)	0.215	< 0.001	0.1/2.0	0.01
Copper (mg/L)	221	0.003	1	0.005
Iron (mg/L)	4660	< 0.001	2	1
Maganese (mg/L)	93.5	0.006	2	N/A
Nickel (mg/L)	0.202	< 0.001	2	0.0001
Lead (mg/L)	0.112	< 0.001	1	0.005
Zinc (mg/L)	851	0.01	5	0.05



*ARD at the Aqua Forte site before and after treatment with ViroMine™ Technology reagents.*

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**CONCLUSION**

ViroMine™ Technology was highly successful in reducing heavy metal concentrations in the Aqua Forte tailings dam to below Portuguese Water Discharge limits.

ViroMine™ Technology has proven to be applicable for the treatment of heavy metal and acidity problems associated with acid rock drainage and tailings dams.

ARD water and contaminated tailings dams can now be economically treated to near-pristine environmental standards, a significant development in water-scarce Portugal.