Community Guide to Biochemical Reactors

What Are Biochemical Reactors?

Biochemical reactors (BCRs) treat mining-influenced water (MIW), which is water that has been contaminated by mining or mineral processing activities. MIW is typically acidic and contains metals, sulfate and other inorganic contaminants. During BCR treatment, the contaminated water moves through one or more treatment cells filled with a mixture of natural materials, such as wood chips, mushroom compost, hay, manure and limestone. These materials cause biological and chemical reactions that reduce acidity and sulfate levels. The materials also decrease concentrations of metals in the water or convert them to safer forms.

How Do They Work?

BCRs are usually ponds or trenches dug into the ground and lined with plastic. They are positioned downhill from the discharge of MIW so the contaminated water flows into them due to gravity. Alternatively, the water is pumped into an aboveground tank. Each pond, trench or tank of a BCR is filled with natural materials. The materials are selected based on how well they can treat the types of contaminants in the MIW.

Water flows through the materials from the top down, and reactions that occur treat the contaminated water. Materials such as limestone, seashells or cement kiln dust reduce the water's acidity. The lower acidity causes some dissolved metals to form solids that settle to the bottom of the BCR, where they can be removed for disposal. Other organic materials, such as wood chips, compost and hay, promote biological activity by feeding **microbes** – very small organisms naturally found in soil. Microbes in a "sulfate-reducing BCR" produce conditions that change sulfate in the water to sulfide. The sulfide will bind with dissolved metals (mainly cadmium, copper, nickel, lead and zinc) to form solid materials that can be removed and disposed of.

BCRs do not work as well during winter and in colder climates when microbial activity slows down. However, a soil or plastic cover installed over the natural materials will reduce heat loss, allowing the BCR to continue operation. A BCR can also be insulated or buried underground to keep it warm.

BCRs are almost always used with other natural treatment methods. The treated water may flow into another cell or tank filled with limestone. Limestone further neutralizes the acidity and removes metals that are difficult to treat with a BCR alone. Water exiting a BCR also may be low in oxygen, which can be hazardous to wildlife. Flow through a rock-lined channel can help aerate the water before it is discharged to a stream.

Wetlands may be constructed using plants to remove low levels of metals that remain in the treated MIW. (See *Community Guide to Phytoremediation*.) Following this final step, the treated water usually is discharged to a nearby stream.

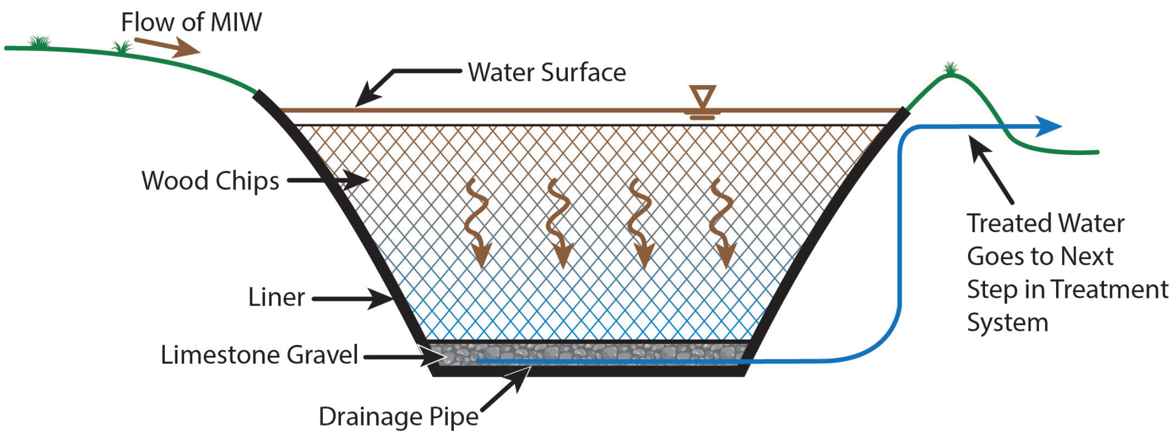
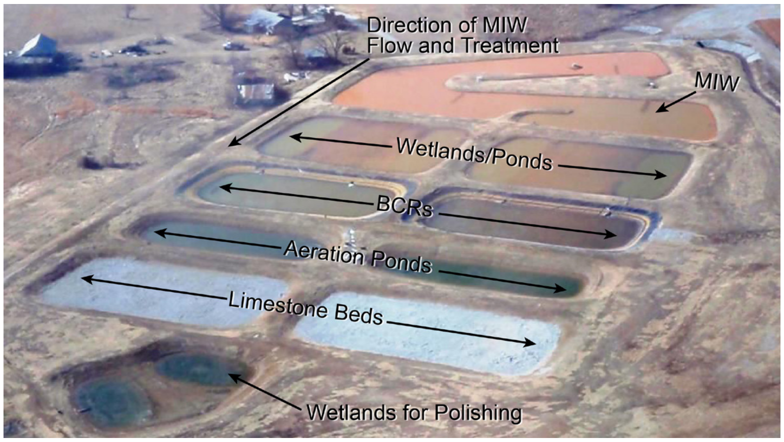


Diagram of a BCR.



BCRs and other treatment cells at Tar Creek Superfund site.

How Long Will It Take?

Treatment time within a BCR may last a few hours to a few days depending on several factors that vary from site to site. For example, it will depend on the:

- Types and concentrations of contaminants.
- Number and size of treatment cells.
- Flow rate of MIW.

The MIW may flow from a source for decades, and the BCR must function the entire time. As a result, BCR materials may periodically need to be mixed or refreshed with new materials to remain effective.

Are BCRs Safe?

BCRs use natural materials and microbes that pose no danger to your community or wildlife. BCRs may be fenced off to prevent entry and damage to the BCR. To ensure that BCRs continue to work properly, they are inspected regularly, and the treated water is tested.

How Might They Affect Me?

During construction, you may notice increased traffic while equipment and materials come to the site. You might also notice noise during BCR construction. During operation, some BCRs can emit a naturally occurring gas called hydrogen sulfide, which has an odor of rotten eggs. However, measures such as aerating the water can minimize odors. The treated water discharged to a stream is clearer than MIW, although you might still see a slight discoloration.

Why Use BCRs?

BCRs can be constructed at remote mining sites with simpler equipment and materials than many other treatment options. They also need less maintenance. Gravity-driven systems require little energy, and if pumps are necessary, they can be powered by solar or wind energy. Materials for the BCR often can be obtained locally, which promotes reuse and decreases transportation needs. BCRs have been selected for use at several Superfund sites and other cleanup sites across the country to treat MIW.

Example

The Tar Creek Superfund site in Oklahoma is in the Tri-State Mining District. For over 30 years, MIW from abandoned lead and zinc mines was discharged into Tar Creek.

In 2008, a treatment system including two BCRs was installed to remove cadmium, lead and zinc from the MIW (pictured at left). MIW first flows into ponds and marshes that trap solids, sediments and some metals. Next, BCRs contain a layer of mushroom compost, hardwood chips and limestone sand placed over a layer of limestone gravel to remove more metals. The water is then filtered through limestone to remove zinc. The system has continuously operated since 2008, with limited maintenance, and water exiting the system has consistently met water quality criteria standards.

For More Information

- About this and other technologies in the Community Guide Series, visit: https://clu-in.org/cguides or https://clu-in.org/remediation/
- About use of cleanup technologies at a Superfund site in your community, contact the site's community involvement coordinator or remedial project manager. Select the site name from the list or map at http://www.epa.gov/superfund/sites to view their contact information.