USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

Title: Compatibility of Containment Systems with Mine Waste Liquids

Focus Categories: GW, TS, WQL

Keywords: Groundwater contamination, Mining, Mine waste liquids, Waste containment facilities

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Statement of Critical Regional or State Water Problems:

Great interest has arisen in metallic mining at various locations in Wisconsin. The Flambeau copper mine was operated in northwestern Wisconsin from 1992 to 1997 and a large zinc and copper mine is being proposed for northeastern Wisconsin. Also, exploration is being conducted at several other sites in western Wisconsin for potential mine sites. Concurrently, significant concern has developed regarding the potential for environmental impacts of mining, particularly the pollution of groundwater. Mining's greatest threat to Wisconsin groundwater is pollution from drainage of mine tailings. Tailings are the residue remaining after benefication of the ore. Drainage from tailings may consist of process water present at the time of disposal (tailings are often disposed in a slurry form) or acidic water caused by percolate passing through tailings undergoing oxidation. Drainage of process water or acidified water can pose a significant threat to groundwater because both liquids usually contain a variety of toxic heavy metals.

Statement of Results or Benefits:

Mine wastes have significant potential to affect groundwater quality in Wisconsin, the region, and the nation. This is a timely issue because of the major debate taking place in Wisconsin regarding metallic mining and the issues faced by the citizens and the regulatory staff in permit review of mines. There is a need to understand whether the containment systems proposed to contain mine waste will be effective in preventing groundwater pollution. This study will assess a variety of lining system materials exposed to several mine waste liquids. The engineering properties (hydraulic conductivity, strength, and durability) of the materials will be tested after exposure to confirm whether the liquids have had an adverse effect on engineering properties.

Nature, Scope and Objectives of the Research:

We will assess the compatibility of lining system materials and mine waste liquids with the intent of determining if materials used for lining systems will function as intended in the presence of mine waste liquids. The study will focus on factors that affect leakage rate (e.g., hydraulic conductivity of barrier soils, potential for defects such as holes and tears, and degradation of drainage layers) because maintaining a very low leakage rate is the key factor to maintain diffusion control of discharge from lining systems to groundwater.

Methods, Procedures and Facilities:

A variety of lining system materials will be exposed to several liquids representative of process water and acidic drainage. After exposure, the engineering properties (hydraulic conductivity, strength, and durability) of the materials will be tested to confirm whether the liquids have had an adverse effect on engineering properties. When changes in engineering properties are observed, additional testing will be conducted to determine why the changes occurred.

The project plan consists of four tasks in which a series of laboratory experiments will be conducted to assess the chemical compatibility of containment system elements. These elements include:

- Geosynthetic clay liners (GCL) – standard and contaminant-resistant (bentonite treated with polymers)
- Geomembrane (GM) – high density polyethylene (HDPE)
- Geotextile (GT) filter and cushion – non-woven polypropylene (PP)
- Geosynthetic drainage material, Geonet (GN) – polyethylene (PE)

Compacted clays will not be tested because their behavior in the presence of a variety of liquids (including mine waste liquids) has been thoroughly studied. Instead, the study will

focus on the geosynthetic materials being proposed for new mine waste facilities, namely geosynthetic clay liners, geomembranes, geotextiles, and geonets. The experimental program is designed to assess how mine waste liquids affect the engineering properties of these materials and the consequent potential for groundwater contamination. For this purpose, exposure to three types of liquids (process water, acidic drainage, and "standard" water) will be investigated.

Related Research:

The lining system used in most municipal and industrial landfills is being proposed for use for mine tailings facilities. The system consists of an earthen liner, a geomembrane, and a drainage collection layer (geonet or gravel and geotextile). The combination of an earthen liner and geomembrane is often referred to as a composite liner (Giroud and Bonaparte, 1989). In some cases a double liner may be used which includes a leak detection layer between two composite liners.

Earthen and Geosynthetic Clay Liners

The earthen liner consists of compacted natural clay (>60 cm thick) or a geosynthetic clay liner (GCL). A GCL is composed of a thin layer (~1 cm) of bentonite clay placed between two geotextiles (Estornell and Daniel, 1992). Because GCLs are easily installed, they are becoming popular as substitutes for compacted clay. In Wisconsin GCLs are being proposed for mine tailings facilities to avoid using the large volumes of clay required for compacted clay liners. However, no GCLs have been used yet in lining systems in Wisconsin. When hydrated with water, a GCL has hydraulic conductivity one or two orders of magnitude lower (i.e., 10^{-9} cm/sec vs. 10^{-7} cm/sec) than compacted clay. Consequently, GCLs can be hydraulically equivalent to thicker compacted clay liners (Koerner and Daniel, 1992; Foose et al., 1998).

Geomembranes

Geomembranes (GM) used in lining systems are thin (1 to 2 mm thick) plastic sheets. In mine waste applications, high density polyethylene (HDPE) is the standard polymer used for GMs. Research has shown that HDPE does not undergo catastrophic change when immersed in inorganic solutions, but its mechanical properties may change (Koerner, 1990), which can lead to a greater likelihood of tensile failure, puncture, or cracking. To date, however, little effort has been directed at assessing whether HDPE is affected directly by mine waste leachates. Immersion in leachate can affect four key engineering properties of a GM essential for long-term waste containment: tensile strength, ductility, puncture resistance, and stress crack resistance. If any of these properties change while a GM is in service, the geomembrane may be breached and the lining system may fail.

Geonets and Geotextiles

Geonets remain effective as long as their ribbed structure remains open under the applied overburden pressure (Campbell et al., 1994). The pressure at which the structure will collapse can be determined by measuring the vertical compressive modulus. Immersion in water has been shown to have little effect on the modulus because it causes minimal change in the polymer structure. However, mine waste liquids may affect the polymer, e.g., causing the net to soften or become brittle.

The geotextile filter can also be affected by mine waste liquids if the liquid induces a change in the polymer structure. If the geotextile fibers lose stiffness, the open pore structure in a geotextile may collapse, resulting in a loss of filtering capacity and permitivity. However, limited testing of geotextiles has been conducted with aggressive fluids (Verschoor et al., 1990). Thus, there is a need to assess how mine waste liquids affect geotextiles. Failure of the geotextile or the geonet will lead to higher leakage rates and result in pollution of groundwater.

References

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