

INNOVATIVE METHOD TO DEAL WITH MUNICIPAL WASTE WATER LEADING TO ACID MINE DRAINAGE IN MINING AREAS - CASE STUDIES

Prof. B. K. Pal and Sunil Kr Bisoyi

Department of Mining Engineering

National Institute of Technology,

Rourkela – 769 008, Odisha, India.

e-mail: drbkpal2007@gmail.com

Introduction

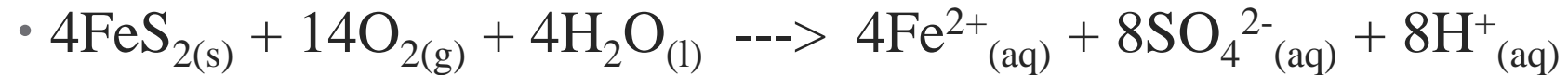
- In the mines, run off water gets polluted by many reasons. During rainy season the mine water generally mix up with the sulphides, particularly iron sulphides and form a yellowish coloured waste called acid mine drainage (AMD).
- When air and water come into contact with pyrite (an iron sulfide), a chemical reaction takes place for which pyrite form sulfuric acid and dissolved iron. This happens when rainwater flows through the site.
- Water flowing through tailings, particularly through debris from mining operations can cause acid mine drainage very easily. This acidic runoff may also dissolve other heavy metals, viz. copper, lead, or mercury, even sometimes arsenic when come in contact with it.

- The metals carried in the runoff may also be at toxic levels. Hence highly acidic runoff not only poses a ground water contamination problem but also a threat to aquatic life. It also poses a great health risk to biosphere.
- There are various methods for treating and mitigating acid mine drainage, including active and passive procedures. In this paper, steps are taken to add up alkaline agents to the water to increase the pH levels of this water. Passive water treatment improves water quality without much of financial investments as the use of these chemicals are cheaply available in the market. Some passive systems like the use of aerobic wetlands, limestone drainage, or diversion wells have also studied. While these treatments are promising, they have yet to be perfected or widely used.

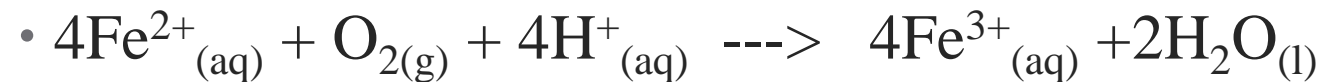
Acid mine drainage:

- The main culprit seems to be iron pyrite (iron II sulfide) widely known as "fool's gold". The level of acidity and the concentration of heavy metal pollutants in the mine drainage can be directly correlated to the amount of pyrite in the area around the mine.

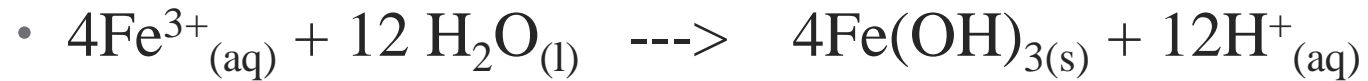
- Chemical oxidation of pyrite described in the following reaction:



- Iron II ions and acidic hydrogen ions are released into the waters that runoff from the mine drainage tunnels or tailings piles. Iron II ions are oxidized to form iron III ions as shown in the following reaction:



- The iron III ions now hydrolyze in water to form iron III hydroxide. This process releases even more hydrogen ions into the aquatic environment and continues to reduce the pH.
- The iron III hydroxide formed in this reaction is called "yellow boy", a yellowish-orange precipitate that turns the acidic runoff in the streams to an orange or red color and covers the stream bed with a slimy coating. Aquatic life that dwells on the bottom channel of the stream is soon killed off. Eqn. 3 describes this reaction:



- Therefore, the concluding equation would be:



Methods to deal with AMD: permeable reactive barriers

- Permeable Reactive Barriers (PRBs) are exactly what they sound like: barriers that react with specific chemicals of concern that are placed in the path of groundwater flow allowing the water to flow through easily (Blowes et. al, 2000).
- This method consists of installing an **appropriate reactive material** into the aquifer, so that contaminated water **flows through the reactive zone**. The reactive material induces chemical transformations that remove the contaminants or otherwise cause a change that **decreases the toxicity of the contaminated water**.

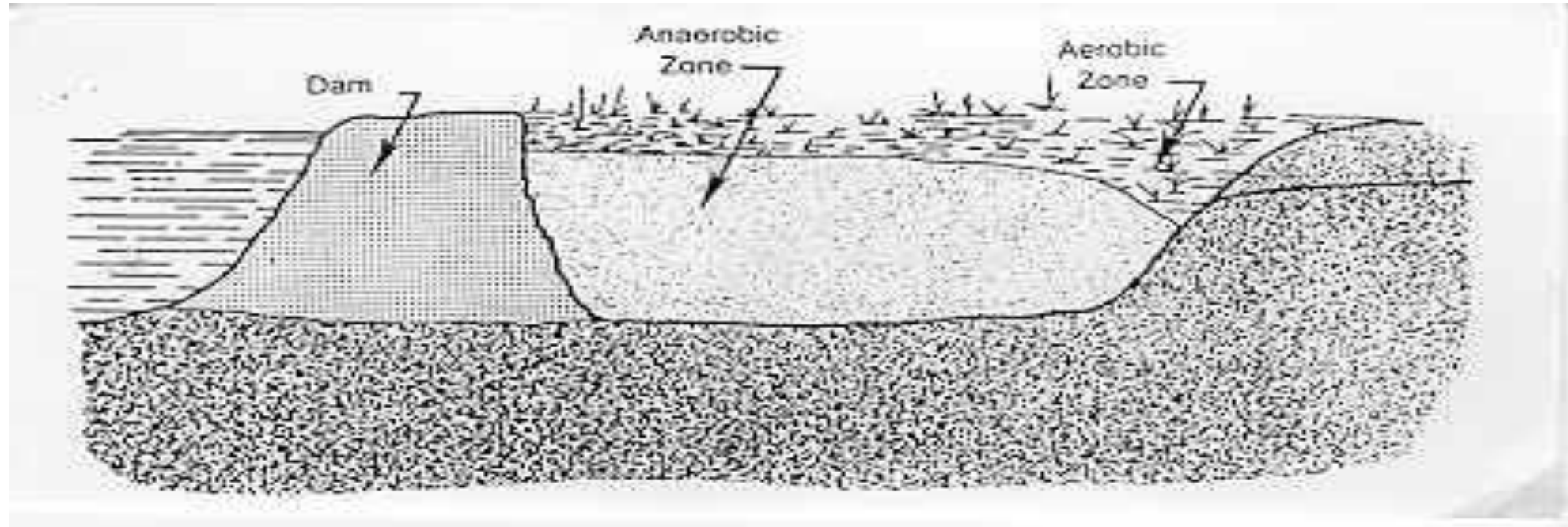


Fig 1: Diagram of constructed wetland passive treatment system

- This research has resulted in the development of contaminant removal mechanisms for a variety of inorganics found in groundwater including As, Cd, Cr, Cu, Pb, Zn, Se, phosphate and Acid Mine Drainage (AMD). Current and past research in this field includes laboratory batch and column experiments, pilot-scale field tests and full-scale reactive barrier installations (Pal and Tandia, 2007).
- The barrier is generally composed of solid organic matter, like municipal compost, leaf compost, and wood chips/sawdust (Blowes, et. al., 2000). Research has been done to evaluate the efficiency of using PRBs to remove uranium contamination at abandoned mine sites; possible reactive materials are zero-valent iron, bone char phosphate, and amorphous ferric oxy-hydroxide (Naftz, et al., 1999).

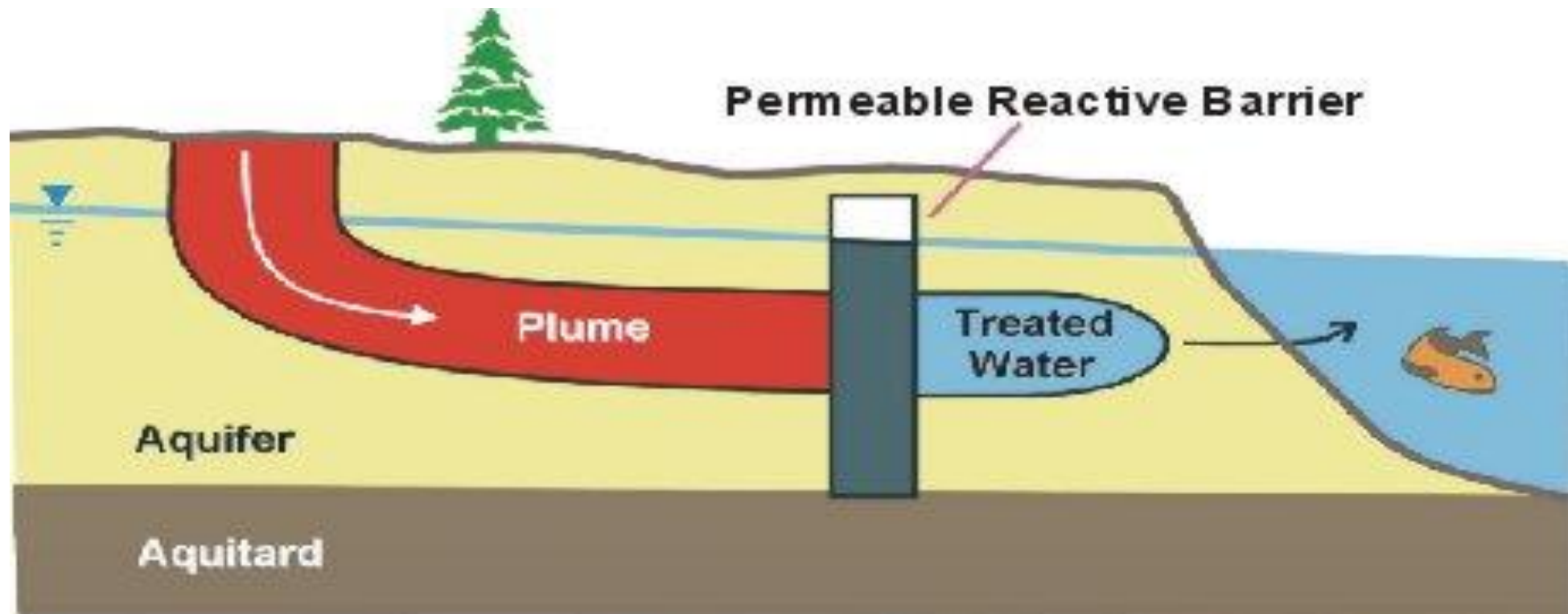


Fig. 2: Permeable reactive barrier

- Although barriers often have very long theoretical treatment lifetimes when only the material and the contaminants of concern are considered, actual lifetimes are considerably shorter due to the presence of other reactive substances in the environment;
- Chemical reactions can be slowed due to depletion of reactive component of the barrier;
- Precipitation of a secondary reactive precipitate can reduce the reactive surface area;
- Physical clogging or preferential path flow.

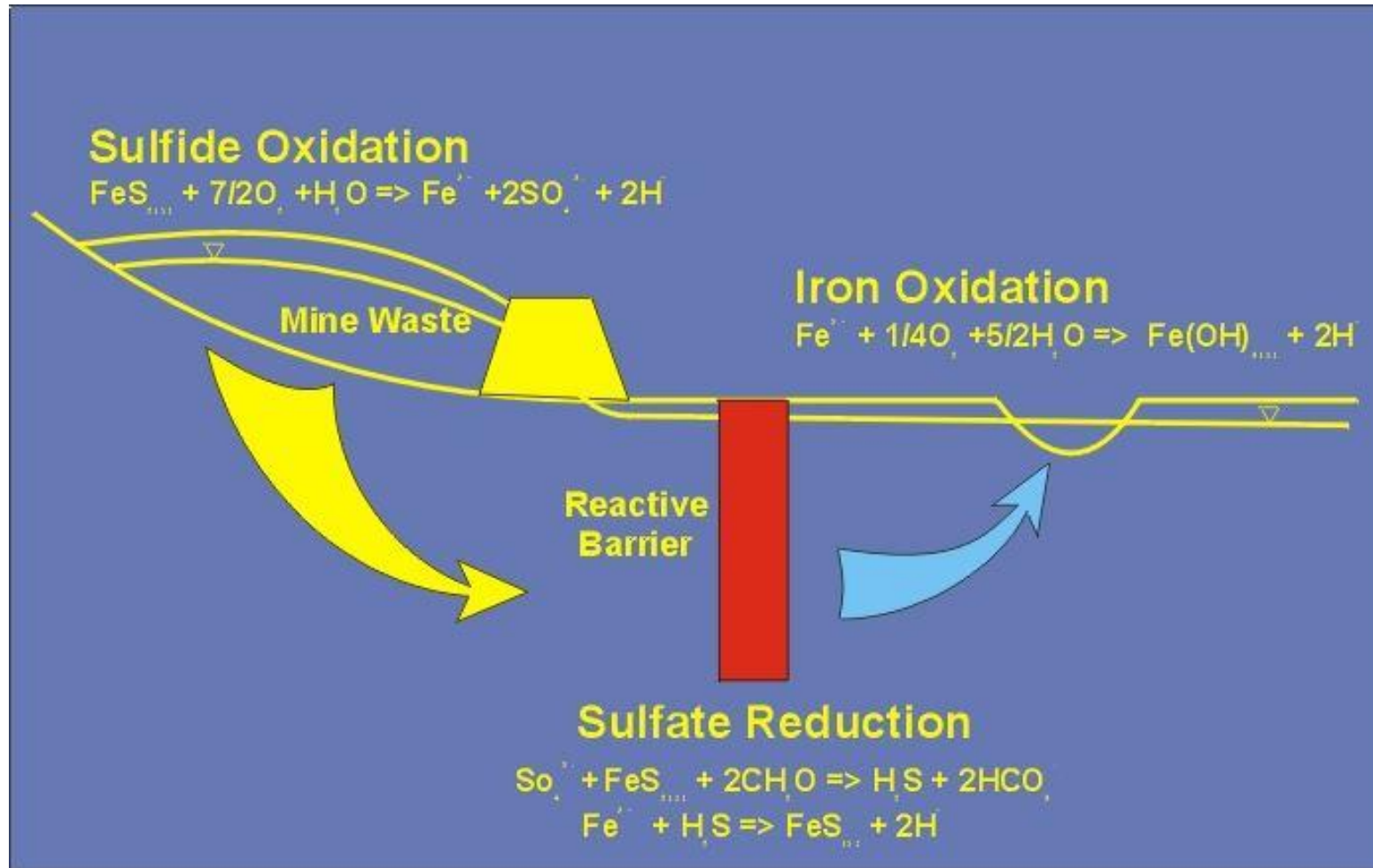


Figure 3: Permeable Reactive Barrier for Treatment of As (Arsenic) and Se (Selenium)

Laboratory Investigations

In common pH values of groundwater (pH = 4-8), arsenic exists as As(III) and As(V). The As(V) oxidation state hydrolyzes to form negative oxyanions and As(III) forms a neutral species. Trivalent As is more mobile than As(V) but both are transported in groundwater. The respective Eastern India and Bangladesh drinking water limits are 25 mg/L and 50 mg/L. The most persistent and mobile Se oxidation state is Se(VI) which also hydrolyzes in water to form negative oxyanions. The drinking water limits are set at 10 mg/L and 50 mg/L, respectively (Patel and Pal, 2018).

Conclusion

Laboratory batch experiments have identified reactive mixtures that successfully remove Se(VI) and both As(III) and As(V) from solution. These optimum reactive mixtures are then used in treatment columns to demonstrate that removal is possible with typical groundwater velocities. Reactive mixtures containing recycled foundry waste, elemental iron and activated alumina capitalize on the unique geochemistry of As and Se for treatment. Surface analytical techniques are then utilized to determine the exact mechanisms of removal. These laboratory investigations indicate that pilot-scale field installations are now possible for the treatment of As and Se.

References

- Blowes, David W., Ptacek, Carol J, Benner, Shawn G., McRae, Che, Bennett, Timothy A., & Puls, Robert W. (2000) Treatment of inorganic contaminants using permeable reactive barriers. *Journal of Contaminant Hydrology*, 45 (1-2), 123-137.
- Brooks, R. R. (ed.) (1998). *Plants that hyper-accumulate metals their role in phytoremediation, microbiology, archaeology, mineral exploration, and phyto-mining*. CAB International: 1998.
- 1.McRae, C.W.T., D.W. Blowes and C.J. Ptacek, 1999. In situ removal of arsenic from groundwater using permeable reactive barriers: A laboratory study. In: *Proceedings of the Sudbury'99 Mining and the Environment II Conference*, September 13-17, 1999, Sudbury, Ontario, 601-609.
- Naftz, David L., Morrison. Stan J., Davis, James A., & Fulter, Christopher (Eds.). (2002). *Handbook of Groundwater Remediation Using Permeable Reactive Barriers: applications to radionuclides, trace metals, and nutrients*. San Diego, California: Academic Press.
- 1.Patel, S. and Pal, B. K. (2018). Adsorption of As (V) from Aqueous Solutions by using Cow-dung Neutralized Red Mud, *Journal of Soil, Air and Water* (Accepted)
- Tandia, P. K. and Pal, B. K. (2007). *Proc. of the 16th Int. Symp. on Mine Planning and Equipment Selection (MPES – 2007)*, Dec. 11-13, 2007, held in Bangkok, Thailand, pp. 780 – 795.

Thank you