Acid Mine Drainage: Effects and Possible Solutions

Outline

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-Example of the effects of AMD

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-current cleanup methods and drawbacks of each method for old mines

-possibility of profit in AMD cleanup

-prevention of AMD in new mines

    -alkalinity of surroundings slows AMD

    -government regulations that make firms accountable for damage

Abstract

AMD is catalyzed by a series of reactions that result in the conversion of sulfide in ore to become acid. The acid causes great environmental damage, as seen in the Berkeley Pit in Butte, Montana. The current methods of alleviating AMD pollution are all expensive and have drawbacks, and it is currently not economical to profit from extracting metal from the waste. Currently, the best solution to the problem is to keep mining companies economically accountable for the environmental damage they cause.

Introduction

Mining ore has been a very profitable process for many companies. Until recently, however, most companies did not take into account the environmental costs of mining. Acid Mine Drainage (AMD) is one of the negative effects of mining. It has the potential to cause large amounts of irreversible damage to the surrounding environment. It may be possible to make the cleanup of AMD profitable, but for now mining should be done with consideration for the surrounding environment.

Literature Review

Acid Mine Drainage (AMD) is a common form of water contamination from mines, where the water becomes much more acidic than normal. It occurs when sulfide containing minerals, mostly commonly FeS or pyrite, are exposed to the surface. Exposure can occur through natural weathering, but it is very common in mines because fresh minerals are frequently exposed to the surface. Once the sulfide minerals reach the surface they react with oxygen in the air and water in the following reaction:

1. $2FeS(s) + 7O_2(g) + 2H_2O(l) \rightarrow 2Fe^{2+} + 4SO_4^{2-} + 4H^+$

In this reaction, four acidic protons are produced for every 2 molecules of FeS, which are part of the acid pollution. However, the Fe^{2+} ions and the H^+ can continue to react:

2. $4Fe^{2+}(aq) + O_2(g) + 4H^+(aq) \rightarrow 4Fe^{3+}(aq) + 2H_2O(l)$
3. $4Fe^{3+}(aq) + 12H_2O(l) \rightarrow 4Fe(OH)_3(s) + 12H^+(aq)$
4. $2FeS(s) + 14Fe^{3+}(aq) + 8H_2O(l) \rightarrow 15Fe^{2+} + 2SO_4^{2-} + 16H^+$

In Reaction 3, Fe^{3+} reacts with water to form a yellow precipitate and acid. This yellow precipitate is referred to as yellowboy, and it discolors water systems and collects on the bottom of streams, which prevents the plant and animal life living there from obtaining oxygen. The death of these organisms can disrupt entire ecosystems (Wikipedia, 2008). However, if the pH of the water is below 3.5, Fe^{3+} will continue to react with FeS in reaction 4. Oxygen is not required for this reaction, and it will continue until all FeS is depleted, which can cause a great increase in the pH of the surrounding environment (Growitz, 2002). Once the pH of the surrounding environment gets low enough, it can dissolve the trace metals in the soil, some of which are toxic. Once dissolved, these metals can get into surrounding streams and soil. These metals, along with acid can act as poison for wildlife. Aquifers and roads can also become damaged by the acid and metals.

AMD has the potential to cause great damage to the surrounding environment. AMD is a naturally occuring process that is a byproduct of weathering of rock (Kesler, 1994). AMD form natural weathering does cause some stress on plant and animal life. For example in areas where natural acid mine drainage occurs, leaves may fall from trees prematurely. However, the effects anthropogenic AMD are far worse than the natural effects.

The Berkeley Pit in Butte, Montana is an example of the true potential for AMD damage. The mine was shut down in 1982, and so were the pumps that prevented flooding. The pit is now flooded with water that is laced with much higher than average concentrations of multiple poisonous metals including aresenic, cadmium, and copper. The water in the pit is so acidic that it killed 342 geese that landed in the pit to drink. The water from this pit has leaked into the Clark Ford River and greatly increased its metal content. Also, the water in the pit is predicted to eventually rise to the point where it will contaminate the groundwater in Butte (Dobb, 1996). Pennsylvania, a state where much mining takes place, illustrates another problem from AMD. There are many streams where aquatic life has been killed by yellowboy (Alcorn, 2007), the compound from reaction 3. It is clear that a solution to AMD pollution is necessary.

Discussion/Analysis

Multiple methods of alleviating AMD in old mines that are no longer in use currently exist. A common method is to neutralize the acid with substances such as limestone or neutralizing rock (Durkinl and Hermann, 1994). The unfortunate side effect of neutralization methods is that they generate waste that must be disposed of (Dobb, 1996). Another method is to introduce chemicals that kill bacteria that catalyze the acid generating reactions (Durkinl and Hermann, 1994). However, this will not stop the reactions entirely, and it introduces other chemicals that have potential to be harmful to the environment. Collection and treatment of the waste is a possible solution, where the waste is collected and treated with base additives or passed through a wetland, but these methods are expensive and do not treat the source of the problem, only the symptoms (Durkinl and Hermann, 1994). Another downfall of solutions is that they are expensive. However, there is a less expensive option that follows from the idea of collection and treatment.

The water is AMD collects metals from the soil, which means the water contains potential resources. An ideal solution to AMD would be to extract metals from this water at a profit. The company Metanetix attempted to do this in Butte, but was not able to make the process economical (Dobb, 1996). However, if this were to become economical, it would give firms incentive to clean up AMD, and the firms would be responsible for the polluted land instead of the government or the surrounding community. Research for extraction of metals from water should receive government funding. There has already been success in making AMD waste useful at Bucknell University, where a professor made paint from yellowboy (Alcorn, 2007). Until it becomes economical, it appears that the best available solution to AMD is to cover acid producing rocks with clay (Durkinl and Hermann, 1994).

New mines that will be mined in the future have another option for dealing with AMD. A common method of decreasing the harmful effects of AMD is to add a basic material. However, if mines were dug in areas that were high in alkalinity, then there would already be basic material present to neutralize the acid. While this is a good concept, most companies will dig where ore is present, whether the surroundings are alkaline or not.

The best way to deal with AMD when there is little alkalinity present is to make firms responsible for cleanup during mining. This will force firms to be responsible in their practices, and they will take the environmental costs of mining into account. Responsible practices will prevent another environmental disaster like the one at Butte. It is much more difficult to alleviate AMD once mining has stopped because damage has already taken place, and firms will try to escape their responsibility to the environment. For now, prevention is the ideal solution.

Conclusion

Mining companies have made many mistakes in the past that have greatly damaged the environment. However, this damage does not have to be in vain. Prevention is an ideal solution to this problem. While the Berkeley Pit and other mines may seem to be beyond repair, they have provided valuable information on the potential effects of mining. The best way to clean up AMD in the future is to learn from past mistakes and use prevention.

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