TOPIC: WATER QUALITY AND MINING

SUB-TOPIC:
PART C: REMEDIATION (OF ACID MINE DRAINAGE)

Supporting Transcript

PRESENTED BY: George Wilson, The University of Manchester
CONTENT COORDINATOR: Dr. Laura Richards, The University of Manchester (Department of Earth and Environmental Sciences)

This transcript accompanies associated presentation slides and video content developed for the TIDE project in 2021, with acknowledgements and disclaimer as noted in associated files.

SLIDE 1

In this lecture we'll be looking at a brief summary of selected mine remediation approaches and we'll be covering this in the context of acid mine drainage. Selected remediation approaches more relevant to drinking water treatment are covered in separate mini-lectures.

SLIDE 2

I'll be briefly covering some of the environmental regulatory context in Myanmar surrounding mining before moving onto remediation approaches and some considerations about remediation selection according to their setting.

SLIDE 3

According to our literature review, mines in Myanmar are subject to regulations to ensure they limit environmental damage to their surroundings. As we've seen previously, there can be adverse effects to mining activities or leaving a mine abandoned with inadequate consideration of the environment. And we'll be describing an example of a remediation selection methodology in this lecture.

SLIDE 4

The objectives are to become familiar with regulatory environment framework for mining in Myanmar, to become familiar with remediation approaches to addressing acid mine drainage and to undertake a simple cost-benefit analysis, for one method to inform selection of an appropriate remediation strategy to an example problem.

SLIDE 5

So first lets briefly cover the environmental mining laws in Myanmar as reported by the Ministry of Environmental Conservation and Forestry.

SLIDE 6

So for the past decade, mines in Myanmar did not have to follow any particular rules relating to the preservation of the environment. In 2015, the government enforced the environmental impact assessment for mines, which meant mine owners now need to consider the risks that mining may have on the environment. This methodology has been applied across the world to think about the risks and how they can be mitigated. Three years later, the Mining Rules 2018 Law was brought in and this told mine owners that they must establish conservation strategies and that they must ensure that the mine is not left to cause problems after its use and so it must be decommissioned properly.

SLIDE 7

There are a number of remediation options available to prevent or reduce mining pollution, and acid mine drainage can be used to exemplify this.

SLIDE 8

There are numerous potential mitigation approaches to acid mine drainage that'll you'll come across in papers and this is partly thanks to every mine being physically and chemically unique. We can't simply apply the same formula to every setting and get the same desired outcome every time. We'll talk more about the selection of technologies in a second, but for now let's discuss what the options are to select from and how they're grouped.

There are two important classes of strategies that we can choose and the first is whether it is active and passive. Active systems require a constant input of energy or resources and are preferred for mines that are currently still running as there are still sources of power, whilst passive systems require no energy input and can be left with minimal effort, although a large treatment area is required. Passive systems are typically better suited to abandoned mines or where infrastructure is limited.

The other distinction is whether the system is biological or abiotic – now both of these can have advantages and disadvantages but we don't have time to discuss this is detail. You can find info in the further resources about this.

SLIDE 9

So let's describe one active/biological strategy and one passive/dry cover strategy to briefly show how these work.

SLIDE 10

Let's take the dry cover first.

SLIDE 11

The dry cover is operated on the premise of different layers with different properties. The clay layer has low hydraulic conductivity to prevent water and oxygen interacting with the mine tailings, however this is susceptible to erosion so a protective layer, such as a geomembrane is placed on top. A layer of topsoil then sits on top of this as small amounts of vegetation are useful to stabilize the cover. Punctures of the sealant layer could occur if large roots are allowed to penetrate this though. Simple monitoring probes are often used to check that the oxygen and water flux does not increase.

The dry cover is ideally sat on top of an impermeable layer, such as a plastic PVC sheet or another layer of clay, to ensure acidic runoff into groundwater does not occur, but in some cases this is not deemed practical or feasible. There are a number of different designs of dry covers so this is only one example.

SLIDE 12

And now the sulfidogenic bioreactor, or SBR as an example of an active process.

SLIDE 13

The idea of a sulfidogenic reactor is that it generates copper sulfate, which can be sold on for profit, whilst treating the mine water. There are numerous designs for these reactors because each mine is distinct in many ways but they all use sulfate-reducing bacteria to treat the water. This particular design is for very low pHs. Here, nitrogen along with acid-tolerant sulfate-reducing bacteria (aSRB) are added to the low pH mine water to precipitate copper sulfate. In this second reactor, hydrogen sulfide produced from the bacteria from the previous step is used to further precipitate out the solid copper. This overall process has the effect of reducing metal concentration whilst producing valuable copper sulfate, as well as increasing the pH of the water.

SLIDE 14

Lets take a look at how we could select an appropriate remediation strategy for acid mine drainage.

SLIDE 15

We had a look at the ways in which we can select a remediation strategy last time and this included looking at the regulatory framework (which may identify minimum treatment standards), available technology as well as environmental impact assessments. And the economic benefits are often measured by the cost-benefit analysis and if we remember this involves factoring in construction, operational, decommissioning costs and also any benefits that the project may bring.

SLIDE 16

And so I'd like to show you specific examples of how a selection methodology like this may work for the remediation of acid mine drainage. In this example methodology from O'Kane and Wels, the cost-benefit analysis is paired with the environmental impact analysis and we'll be looking at this in context of a proposed cover for mine tailings and also another alternative solution. The idea is that both assessment tools are carried out before a detailed design is made, and adjustments to the design are made based on the outcome of these tools. There may be small tweaks or adjustments to the project based on a cost-benefit analysis or the impact assessment once the outcome is reported. Or if there is a too large risk identified in the impact assessment or too much of a loss predicted from the cost-benefit analysis, the whole approach might need to be changed. The cost benefit analysis is a universal tool for environmental projects and is worth looking at in more detail. You'll also be creating one of these in the practical session using an example spreadsheet that will be provided.

SLIDE 17

And so now we'll have a look at two example cost benefit analysis of two possible solutions to an acid mine drainage problem in Agrokipia acid mine lake in Cyprus, which has currently been left without any remediation implemented, after mining activity has finished
Solution 1 is the dry cover. The dry cover consists of two layers – a bottom, impermeable sealant layer and a protective layer on top, like that we spoke about before. And so if we model the cost benefit analysis for this solution, let's see what the result is.

SLIDE 18

We can use a probability of non-exceedance versus net present value as a useful tool for this purpose. This tells us the likelihood of the project exceeding, or not exceeding a certain value. Present value is just a way of saying before any inflation is considered. So for the first solution, the dry cover, there are very high costs associated with initial construction materials and might mean this project will likely not make any money. Just to explain what the graph means a bit more, here we predict that there is 100% chance, or a probability of 1 that the project will not exceed a profit of negative 1 billion kyat. This is the predicted maximum possible profit from the modelling. We predict there is a 50% chance, shown by the P50 line, of the project not even exceeding negative 2 billion chat, and you can read off at any point to see that this project is modelled to lose a large amount money. The cost of covering such a large area with that much material is not beneficial economically

SLIDE 19

And so the second solution involves using a sulfidogenic reactor on the same site. Now this time, overall profit *will* likely come about, and this is because of the large benefits from the recovery of metals in the process. The profit is modelled to be in the range of negative 20 million and positive 160 million kyat. There's an approximate 10% chance of the project not making profit, if the costs turn out to be high or the benefits turn out to be lower than predicted, or both.
But its important to remember that these are highly situational – just because the sulfidogenic reactor turned out the be more profitable in this cost-benefit analysis, doesn't mean this will be the case for every setting.

SLIDE 20

And this is what an example cost sheet may look like. Don't worry about the specific numbers in the table but do appreciate that there are different types of costs and that for this reactor there are large benefits, from the recovery of copper and the value put to the purification of the water.

SLIDE 22

In summary, recent regulatory changes in Myanmar over the past decade have increased environmental assessment and protection associated with mining activities. A range of remediation and monitoring solutions may be used and these can be grouped as passive or active and biological or abiotic. And finally the selection of such remediation is a multi-step process and a cost-benefit should definitely be considered as a tool for costing analysis.

SLIDE 24

For the learning exercise, I'd like you to have a go at running your own cost-benefit flowsheet for a potential mine remediation project, of any type of activity. This may require a bit of research into the costings of the remediation scheme, but don't worry too much about this, its only to see how we would set this up. I'd like you to think about whether the cost and benefits you have put into the spreadsheet will likely result in profit or a loss, and how you could think about making profit more likely if you've got large losses predicted.

SLIDE 26

Here are the references used in the PowerPoint.

SLIDE 27

Along with some further resources, all of which are open access. There is a video link for a guide on how to produce a simplified cost benefit flow sheet, if you want to try this from scratch.

SLIDE 28

Please note the disclaimer and conditions for use of these slides.