Acid Mine Drainage: devastating to aquatic life

Summary

Acid streams resulting from mining activities from certain types of mineral deposits such as those at Rapu Rapu are highly toxic to the aquatic environment. The extreme acidity is toxic to most aquatic life and even after neutralisation the precipitate formed continues to affect aquatic organisms. Toxic elements, such as copper, cadmium and zinc are often associated with acidic mine drainage, contributing substantially to the devastating ecological effects of acid mine drainage.

An outflow of acid mine drainage from the Lafayette mines in Rapu Rapu into the sea would undoubtedly affect local marine life. It could silt up corals causing coral mortality and cause the depletion of bottom dwelling organisms, which would have domino effects up the ecosystem, reducing the food sources available for animals at the top of the marine food chain, e.g. sharks. The toxic elements could also be taken up into the marine food chain, causing long term health effects to marine life, and some may bioaccumulate up the food chain.

Although AMD can be treated at the mine to some degree, e.g. by neutralisation at source, this process is never fully efficient. Furthermore, accidents with the treatment system are inevitable. Earthquakes, tropical storms and typhoons occur regularly in the Philippines. These could cause tailings dams to break or cause flooding, sending a large pulse of either acid mine drainage, or the precipitate downstream, which could have devastating effects on corals and marine life. Mining accidents with this type of mine have occurred recently in Europe and also in the Philippines. These have resulted in adverse environmental and ecological effects, with the possibility of, as yet unquantified, long term impacts.

Therefore, Greenpeace demands that there should be no mining in Rapu Rapu because of the risk of severe adverse effects on the corals and marine life. Lafayette's discharges flow into the Albay Gulf, an acknowledged migration path for whale sharks and five out of seven of the world's marine turtles, thus, making it wholly unsuitable for a mine site.

What is acid mine drainage?

Acid mine drainage is predominantly caused by the weathering of pyrite. Pyrite oxidises to produce very acidic waters (pH < 3), which can solubilise heavy metals and other toxic elements and cause them to be transported downstream, eventually ending up in the sea (Pentreath. 1994; Jenkins et al., 2000.)

Pyrite is a mineral composed of iron and sulphur (FeS_2), often called "fool's gold" because of its gold colour. Pyrite sometimes occurs in large quantities in various types of mineral deposits, such as that at Rapu-Rapu. In addition to pyrite, these mineral deposits often contain other, much more valuable metals such as copper, zinc and gold, which are mined. Pyrite, however, is not normally mined. One extremely r toxic metal associated with these types of mineral deposits, but not necessarily mined, is cadmium.

Mineral deposits containing pyrite are usually present as sulphides, deposited in the layers of rock beneath the earth's surface, where there is little or no oxygen. When mining occurs, these deposits are brought to the surface and crushed. The mineral deposits are crushed, the valuable minerals containing copper or zinc or gold taken out and the waste rock containing pyrite is left at the mine site. Thus, large amounts of pyrite become exposed to surface air and water the pyrite weathers, or oxidises. Although acid streams can occur naturally (e.g. Yellowstone National Park, USA), most are a result of mining activities giving rise to acid mine drainage. (Jenkins et al., 2000.)

The weathering of pyrite produces acid. The sulphide in pyrite oxidises to sulphate, to become sulphuric acid. The iron in pyrite also oxidises or rusts, which drives the reaction further. Specialist oxidising bacteria that can survive the extreme conditions catalyse the reaction. Crushing also increases the rate of weathering, which increases the surface area exposed to the atmosphere. Hence, the weathering of pyrite in mine-waste proceeds quickly compared to normal weathering of rock and mine wastes containing pyrite can produce extremely acidic waters. The reactions go on, not only during the life of the mine, but also for many decades and even centuries beyond.

The acid waters dissolve many of the minerals present causing iron and potentially toxic elements from the ore, such as copper, cadmium and zinc, to be solubilised. The waters are then discharged into a stream and, at Rapu Rapu, into the sea. The acidity can be neutralised slowly by the stream or rapidly by the ocean.

Whilst copper and zinc are essential trace elements for plant and animal life (including humans), at higher doses they are toxic. There are no known beneficial properties of cadmium. It is highly toxic to plants, animals and humans and many aquatic species are very sensitive to cadmium. When present in bioavailable forms, bioaccumulation has been observed in both aquatic and terrestrial organisms (Savinov, 2003)

Environmental and ecological effects of acid mine drainage

Acidity and metal toxicity

The high acidity of acid mine drainage and the high amounts of dissolved heavy metals (such as copper and zinc) generally make acid mine drainage extremely toxic to most organisms (Pentreath, 1994). Many streams derived from acid mine drainage are largely devoid of life for a long way downstream.

Sedimentation

Drainage water from acid mine drainage is initially clear but turns a vivid orange colour as it becomes neutralised because of the precipitation of iron oxides and hydroxides. This precipitate, often called ochre, is very fine and smothers the river bed with a very fine silt. Thus, small animals that used to feed on the bottom of the stream or ocean (benthic organisms) can no longer feed and so are depleted. Because these animals are at the bottom of the aquatic food chain, this has impacts higher up the food chain into fish. So, even if the acidity and heavy metals are neutralised, acid mine drainage still affects wildlife a long way down stream because of these indirect effects.

In addition to killing bottom dwelling organisms, this smothering ochre or orange precipitate reduces the amount of gravel for fish to lay their eggs on, and hence affecting fish breeding. (Pentreath, 1994). The sediment also contains the toxic elements that were dissolved in the acid mine drainage before neutralisation. These are now transported as particulates downstream and, eventually, into the sea.

Effects on marine ecosystem

Acid mine drainage will be neutralised by the sea, unless it is already neutralised. The ochre (orange precipitate) may be formed in the sea as the stream enters the sea, or the ochre is formed in the stream and washed in to the sea by the stream (e.g. at high flow). Either way, the ochre will increase sediment loads carried into the sea in the vicinity of Rapu Rapu. although some ochre may be carried away by ocean currents.

It is not clear what the effects of acid mine drainage would be, but adverse effects from the mining are highly likely. Similar effects of the precipitate would be seen in the marine environment as the fresh water. The coral reef surrounding Rapu Rapu is highly likely to also be affected by the ochre precipitate. The ochre will increase smother the coral reefs in the vicinity of the stream estuary, causing coral mortality. Again, this will not only affect the coral reef itself, which is a valuable ecosystem, but there are likely to be knock-on effects up the food chain.

The ochre precipitate could reduce the area available for fish to lay their eggs on by smothering the seabed near the estuary, hence affecting fish breeding. The smothering would cause loss of bottom dwelling organisms on the seabed, having domino effects up the food chain by reducing the food sources available for animals at the top of the marine food chain, e.g. fish and sharks.

There is potential for acid mine drainage to influence the food chain in the near vicinity, resulting in possible negative effects on the whale shark and other marine life.

Not only could there be a reduction in the area available for fish spawning caused by the smothering ochre precipitate, but this ochre contains toxic elements such as copper, cadmium and zinc.

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Accidents do happen

Can AMD be controlled?

Although AMD can be treated at the mine to some degree, e.g. by neutralisation at source by limestone, settling and tailings ponds or wetlands, this process is never fully efficient. Furthermore, accidents with the treatment system are inevitable. Earthquakes, tropical storms and typhoons are known to occur in the area. These could break dams, or cause flooding, sending a large pulse of either acid mine drainage, or the precipitate downstream, which could have devastating effects on marine life. Indeed, similar accidents have happened previously, both in the Philippines and elsewhere.

Learning from history

a) Aznalcóllar, Southern Spain. In April 1998, a tailings dam at a zinc mine in Southern Spain ruptured and caused the largest environmental pollution accident recorded in Spanish history. The tailings were highly acidic as a result of pyrite waste rock and contained predominantly iron and sulphur with copper, zinc, lead and arsenic. As the dam broke, an estimated 2 million cubic metres of black acidic, metal-rich sludge and water flowed down river to the estuary, Doñana (Grimault et al., 1999). This area is an internationally important wetlands area for resident and migrating birds but became coated in a layer of toxic mud.

All fish and shellfish present in the watercourses of Doñana died and tonnes of dead fish were collected from the area. Emergency clean up measures costing 200 million Euros, such as removal of the toxic sludge and setting up a water treatment plant help alleviate the disaster, but contamination from the spill still persists (Tovar-Sanchez et al., 2006). Follow up studies indicate that arsenic and copper liver levels were elevated in waterbirds that died in the months after the spill. Copper and zinc have entered the food chain (Taggart et al., 2006), whilst arsenic may be a long-term risk to species feeding on roots of aquatic plants as these have become coated with arsenic containing ochre (Taggart et al., 2005). Thus, the tailings spill in Spain not only had catastrophic short term effects of this tailings spill, there are likely to be long-term effects on wildlife.

b) Marinduque, Philippines. In 1996, a severe spill occurred from a tailings pond at Marcopper Mine, Marinduque, when over 1.5 million cubic metres of mine tailings flowed down the Boac river and into the sea. Subsequent studies have made this a well documented case of the impacts of acid mine drainage and mine tailings on heavy metal concentrations in the river and marine environment. Coastal sediments near the river outflow contain high amounts of copper, manganese, lead and zinc and there are concerns that the toxic metals are persisting and may be taken up into bottom dwelling organisms and hence into the food chain (David, 2002). Corals in the area show bands of high toxic metal concentration, which have been dated to the 1996 spill. There is also evidence of high sedimentation rates in the corals compatible with ochre precipitation (David, 2003). The impacts on the health of the coral and reef as a whole are, as yet, unknown.

These spills are evidence that a similar occurrence at a fully operational Rapu Rapu would result in increased acidity in rivers, increased sedimentation on corals the environment and increased concentrations of toxic elements in the riverine and marine ecosystems, with possible long term effects.

Conclusion

An outflow of acid mine drainage from Rapu Rapu into the sea would undoubtedly affect local marine life. It could cause coral mortality and the depletion of bottom dwelling organisms, which would have domino effects up the ecosystem. The toxic elements could also be taken up into the marine food chain, possibly causing long term health effects to marine life, and some may bioaccumulate up the food chain.

Mining accidents with this type of mine have occurred recently in Europe and also in the Philippines. These have resulted in adverse environmental and ecological effects. Therefore, Greenpeace demands that there should be no mining in Rapu Rapu because of the risk of severe adverse effects on the corals and marine life. Lafayette's discharges flow into the Albay Gulf, a migration path for whale sharks and five out of seven of the world's marine turtles, thus, making it wholly unsuitable for a mine site.

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