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Crab shells to Clean Mine Water

By Gunter Pauli

This article introduces a fresh approach to purifying water as one of the 100 innovations that shape "The Blue Economy". This article is part of a broad effort to stimulate entrepreneurship, competitiveness and employment.

The Market for Mine Remediation

The capital cost required to remediate closed mining operations worldwide is estimated to be in excess of one trillion dollars. The remediation of one single mine in California closed in the 1960s required $200 million in tax payers money just to contain the problems of leaching, groundwater contamination and erosion. While all mining companies that are publicly quoted have made provisions for stabilizing and restoring the environment, the amount of cash needed to redress mine dumps, acidic water contamination, heavy metal pollution has increased ten-fold over the past few years as new standards of mining are imposed. If some mining companies were to provide for the full costs according to the latest standards, then these firms could suffer a major drop in their stock market quotations, some would even have to declare for bankruptcy.

Mines either use water and gravity to extract valuable minerals, or crush rocks into fine particles and then extract the ore using chemicals. Large mining operations, open pit or underground tunneling, divert rivers, remove whole ecosystems, even villages and communities in order to reach the desired ore with high levels of efficiency. Mining operations release acid water, sulfuric acid by exposing pyrite to oxygen and water, radioactive materials which are naturally present, as well as additives like cyanide. Countries are increasingly subjecting new mining licenses to the approval of a closure plan before starting the operations. The Province of Quebec (Canada) goes one step further and requires a financial guarantee equal to 100 percent of the calculated remediation cost.

The storage of waste in open pits used to be an acceptable practice, but just like river or submarine dumps, these methods are under increasing attack, forcing mining companies to reconsider their approach. The release of acid water is often controlled by adding lime stone. Tailings are most often stabilized by sequestering the contaminants in and around the roots of plants. This is cheap, and reduces both wind and water erosion that otherwise would expose people and nature. Plant remediation makes the contaminants less available to wildlife and cattle, thus blocking the accumulation into the food chain. As ore becomes more valuable, and extraction techniques more sophisticated, tailings are increasingly reprocessed to recover ores. This has been successfully implemented in Australia.

The Innovation

The increase in cost and the imposition of stringent rules forces the industry to be innovative. The conversion of a series of open pit mines into hydro-power stations has been explored in Ghana, but not pursued. The introduction of algae and bacteria to process waste have been tried, even fungal treatments have been tested. However none have been mainstreamed due to the perceived high cost, the uncertainty and the reluctance of the industry to embrace innovations for which they have no in-house expertise. The sheer volume the mining industry needs to deal with puts a major burden on any creative approach. Unfortunately, an increasing number of mine closures end up with litigation, whereby parties end up paying large sums in compensation after sometimes decades of protracted legal wrangling, with the legal service providers often earning the majority of the cash tabled.

Tyler Barnes is only a senior at Northwestern High School in Kokomo, Indiana (USA). Inspired by Patty Zech, his teacher he learned about the problems of acid mine drainage, a challenge throughout his home state that has a long history of strip mining. A picture of the orange water looked like a painting on the wall, but instead of being artwork with a paintbrush, it was real pollution that kills fish. The mines, as Tyler learned not only pollute and leave a desert-like landscape, they turn the water acidic for decades after their closure, making aquatic life impossible. The mines in Indiana currently use limestone - also locally mined - to reduce acidity. The problem is that limestone does not address the full spectrum of problems, since it does not eliminate dissolved iron or copper in the water. The high rust concentrations threaten local biodiversity beyond repair. Already as a freshman in school, Tyler wished to move beyond the analysis of the problem and started searching for solution, scanning all possible waste materials that could solve both the problem of acidity and absorb the metals.

He decided to focus his attention to find positive answers to a well known problem. Tyler questioned numerous alternatives with few real chances of success until he read about the characteristics of chitosan, an abundant industrial waste from shrimp and crab shells. He pursued his research for four years, often spending hours after school. He went out to collect samples from drainage ditches as far as Brazil and while he could see that chitosan was doing the job, he could not explain why. Then, Tyler created his own acid mine drainage samples, and was mentored by a college chemistry teacher searching for an explanation why it worked. Finally he discovered that the amino group in the chitosan molecule absorbs iron and copper, cleansing the water, while balancing its pH.

The First Cash Flow

While Tyler has already been accepted to Indiana University to pursue a degree in biochemistry, he is wondering how to put his discovery into practice. He is well aware that chitosan is more expensive than limestone, however as everyone in the industry and the government knows, limestone does not improve the chance of survival of aquatic life. He is convinced that it will require legislation to force mining companies to both balance the pH

and remove the metals. On the other hand, chitosan is a byproduct from the natural water bodies, thus he encountered a solution “from the water for the water”. In the process he learned a lot of biochemistry and his presentations on the subject earned him numerous awards in science fairs.

The Opportunity

The world market for chitin-derivatives like chitosan will reach 13,700 metric tons in 2010 and is expected to increase to 21,400 metric tons by 2015, good for a value of $63 billion. This waste material is a biopolymer with the remarkable property of binding with lipids, fats, and metals. As demand further increases with multiple innovative uses, the recovery of the skeletons of shrimps, lobsters and crabs will improve, creating new opportunities for shrimp farms to diversify their revenue streams. The opportunity that Tyler spotted, is that the high grade chitosan can be used for medical, nutraceutical, and food supplements, while the low grade could respond to the immediate need to neutralize pollutants in water. This cascading of material while resolving issues of the past in a positive way, generating jobs, is an example of the mind set with which The Blue Economy approaches development.

Most of the world’s supply of chitosan is consumed in the Asia-Pacific region, responsible for half of the world’s demand. The Japanese market has abundance of water, but a scarcity of pure water resulting in an increased demand for chitosan as a flocculent. Whereas the proposal of Tyler has still major hurdles to overcome, his focus and clarity, based on years of scientific exploration even at very young age, demonstrates that when young people are given the chance they can indeed change the perspective on problems that have been lingering around the world. The solutions may (!) very well lead to an increased demand for chitosan, thus converting a waste stream into a revenue stream while generating jobs especially in regions with urgent need for employment. Therefore, the kind of scientific research combined with exploratory problem solving as undertaken by Tyler inspires not only to research and to learn science, but also think beyond the obvious and make this happen as entrepreneurs should in order to steer society towards sustainability.

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Further information on the 100 innovations at www.theblueeconomy.org

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