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MINE DRAINAGE BIOREMEDIATION - THE EVOLUTION
OF THE TECHNOLOGY FROM MICROBES TO BIO-CARB

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Abstract. Mine drainage, normally acidic by nature, is the usually unavoidable discharge of metallic waste products in water from mine disturbed lands. The indigenous flora and fauna of the aquatic and terrestrial systems receiving this discharge are more times than not adversely affected. The advent of the phenomena of acid precipitation(1) in the last 20 years has further complicated the problem, and even stricter N.P.D.E.S. effluent standards further restrict conventional treatment methods. Bioremediation, the use of natural, harmless, environmental microbes to both achieve and maintain enforced standards, has proven to be a viable alternative in those areas where it is presently being used. It is an old technology that nature has used successfully for untold millions of years and one that I observed over 20 years ago in a mine site in West Virginia. Today, that technology can be successfully implemented at any mine site to clean the water and soil and/or extract more metals from tailings ponds. It is effective and appears to be a permanent solution to mine drainage and the affects of acid precipitation environmental alterations.

Introduction

The observation of a small acid mine slip, separated by rocks and forming two small pools of similar sizes near a coal mine in Fayette County, West Virginia was the beginning of this bioremediation technology. One pool had only a few common mine bacteria and continued to impart the reddish-orange color to the rocks and debris associated with mine waste effluent. The other did for a short distance, then flowed out colorless and clarified. Tests showed the iron in both to be about 6 ppm. Where the two discharged, the colorful one was 5.7 and the clear one showed on 1.5 ppm iron. Why? The answer lies in the mixatrophic population that naturally occurred in the clarified water, but was lacking in its counterpart.

To apply this to the treatment of large mine sites requires more than just "dumping bugs" into treatment ponds. Which microbes do you use? How do you know if they'll work on a specific site? Will they drop out the metals? Will they raise

the pH? Will they create ecological chaos in the receiving waters? How many gallons of water a minute will they treat? How many ponds will it take and how deep should they be? Do they build up sludge? Will it work forever? How fast do they work? Will I meet compliance by lunch tomorrow? How soon can you deliver? How much does it cost and what guarantees do I have?

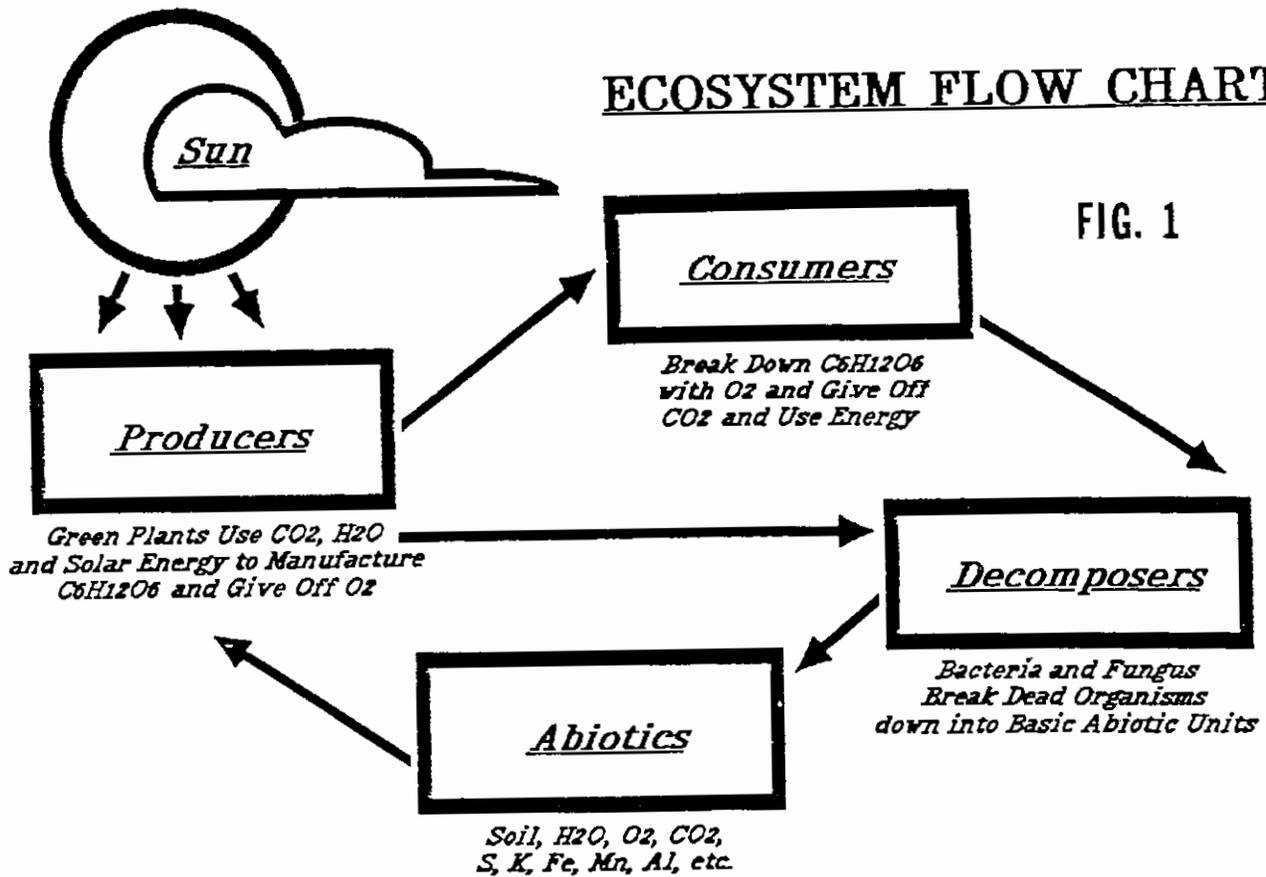
Those are all valid questions - those and more that we ask ourselves every time we install the process. Each answer and each site we do leads to knowledge and understanding of this new technology that has led Lambda from chance microbes in a small pool to the Bio-Carb technology.

The Lambda Process

The microbes we employ are those that will chelate or bond to metals, microbes that produce oxygen, decomposers and nitrogen-fixers, reducing organisms in the soil and any others that are needed to maintain an ecological balance in the system (See Fig. 1). We know from hundreds of tests what the microbes can do. To find

out if they work on a specific site, we have to analyze that site to see what it has that we know we need and what it is lacking at least in adequate numbers to do the job. We can foresee a generic mix that can be modified slightly from site to site. Each site we do brings use closer to that. They can raise the pH to the historic norm of the area, but effluent pH standards 6-9 are unrealistic at best, unless you are discharging into a trout farm. Average rain water pH should be 5.5 (that has been lowered considerably by acid precipitation in the last 20 years(1), but that is another paper entirely), and the average of Appalachian water runs considerably less than that. Therefore, soda ash or mild caustic as an effluent bed prior to discharge is often in order. They are harmless organisms indigenous to the area, or we do not use them.

ECOSYSTEM FLOW CHART



Matter Cycles and Energy Flows through the System

The flow rates are of concern, but can be handled by a properly engineered site and by imbedding the microbes in a substance that will stay on the bottom and not flow out with the water. We feel we need a retention time in the ponds of at least 24 hours to give the microbes time to chelate, oxidize and deposit the metals into the top soil at the bottom of the ponds. This is in a mature system and it takes an inoculated system 1-12 months to mature. Newly constructed ponds leak both water and microbes and an adequate population can't become established as long as they are leaking.

The major evolution in the technology has come in the area of how to most efficiently "imbed" the microbes. The use of the old IMPPS technology required a tanker truck for delivery and was expensive. The material we used kept the microbes alive and active and provided food and moisture and we were transporting a lot of water to keep them moist during the trip.

We are now using diatomaceous earth and activated charcoal. We can add a liquid substance to the growth mediums that suspend the microbes around the diatom skeletons or charcoal particles in a "dehydrated" state that will rehydrate with

a 90-95% recovery ratio. Their effectiveness is seemingly unimpaired and 200 lbs. of that material ships easier, is easier to install and less messy than liquid medium.

We have found that 3 ponds of equal size, which is determined by how much water we are treating, at least 5-6 ft. in depth are needed, with at least 15" of fill dirt or top soil are best. These should be divided by spillways with straw and sandstone rip-rap for deposition purposes, since limestone coats and becomes impervious too quickly. They should empty into

a fourth round solar pond about 2 feet in depth and then discharge thru soda ash or mild caustic to achieve pH requirements. Only one inoculation is required, unless there are major changes in the system. Once in compliance, it should hold compliance. And no, they do not build up "sludge". The sludge is the result of caustics and metals in combination. Remove the caustics and you remove the sludge problem. On the soda ash at the end, you remove the metals and you remove the sludge. We have seen no sludge problems on our sites and have, in fact, used a "sludge pit" as a fourth or "polishing pond" to the benefit of the water and the sludge. The critters tend to break the sludge there into soil.

Negative Feedback Flow Chart for Natural Population Control

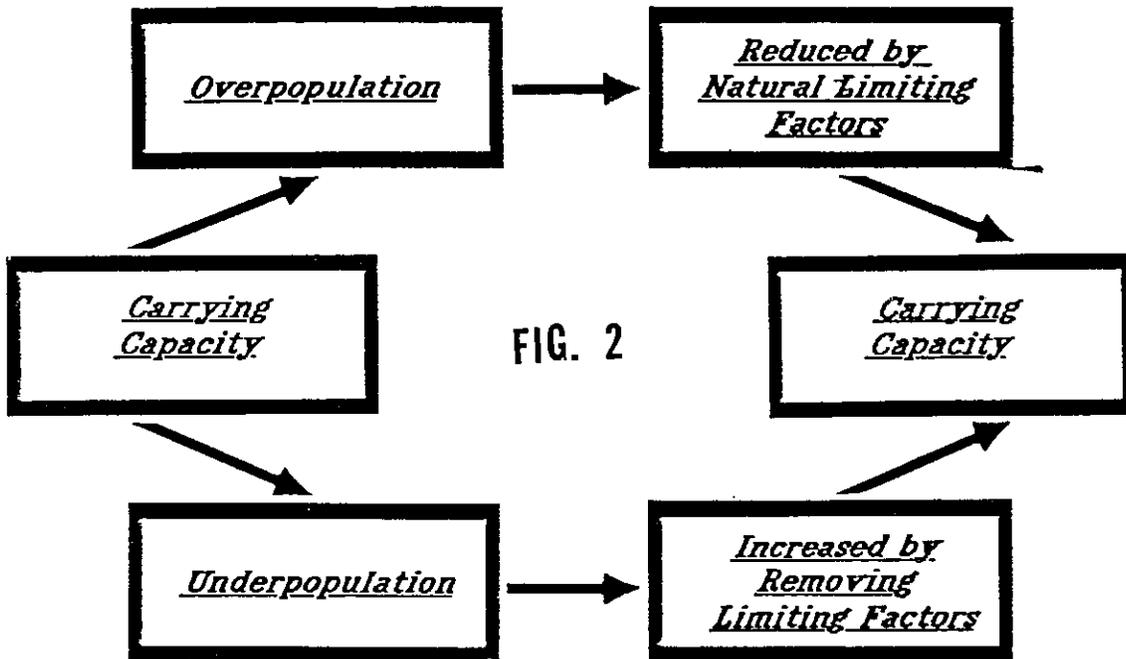


FIG. 2

Compliance comes with maturity. The bigger the system, the longer it will take. The microbes reproduce and populate very quickly, but it does take a reasonable period of time. Will they outgrow the system and develop a blob large enough to eat Charleston? No, they will not. They are controlled by a natural cycle called the "Negative Feedback System" (Fig. 2) and won't grow beyond their carrying capacity. Its nature's birth control system and highly effective. They don't die if the system dries up either. They have slime coats that make them efficient chelators, help them adapt to environmental stress and encapsulate them if the moisture is removed from their environment.

It takes 6-8 weeks to do a site study and identify what a site has and needs and another 3-4 months to grow enough for a site, imbed them all and get them ready to ship. The cost is affordable and will vary from site to site. When compared to treatment costs over 1-2-5-10 years, it will save mine owners money. As far as guarantees are concerned, we won't take a job we can't do.

Site Studies

The technology has been successfully used at 3 mine sites over the last 3 years and 2 other non-mine sites where metal pollution was a problem. Two of these sites, The FT. HILL MINE in Somerset Co., PA, and the ROBINHOOD MINE in Twilight,

WV, have been reported at previous conferences (2)(3) and a summary of the data is presented in Graphs 1 and 2.

Graph 3 refers to the BOILER MAKER'S Pond and the HICKORY CREEK Pond data is show in Graph 4. These last 2 are stationary ponds. The Graph 3 pond is fed from a heavy metal containing aquifer from a pipe that flows up to 25 gal. per minute for 2-3 hours per day. Graph 4 is a pond that receives primarily surface run-off and some enhancement from a groundwater pipe with a much lower metals concentration. Both were built for decorative reasons.

The process has only recently been installed at the LECKIE SMOKELESS COAL MINE into one of their treatment areas. Inadequate data was available at the writing of this paper to include, but from personal correspondence(4), compliance is anticipated and treatment costs have already been reduced by 50%. This is an interesting site, because it had been treated with anhydrous ammonia for 2 years before the BIO-CARB process was tried. The complexing of the metals by the ammonia makes them inherently less susceptible to bioremediation than does treatment with other caustic forms. These problems will be addressed in a future paper.

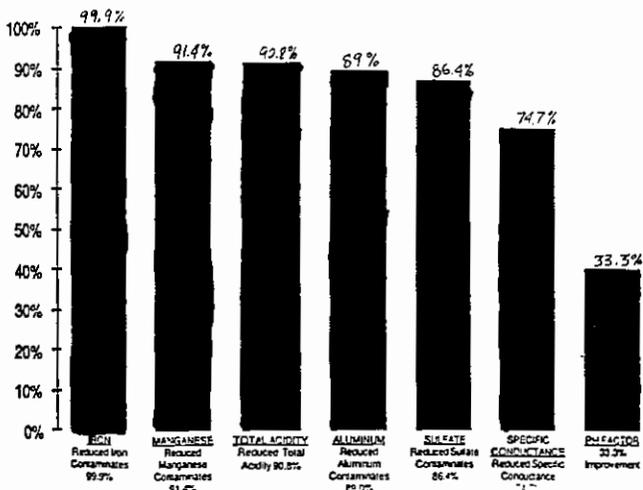
Results of Site Studies

We were able to achieve a 99% reduction in iron at the Robin Hood site, and a 99% reduction in iron at the other sites.

RESULTS SUMMARY
PERCENT EFFECTIVE

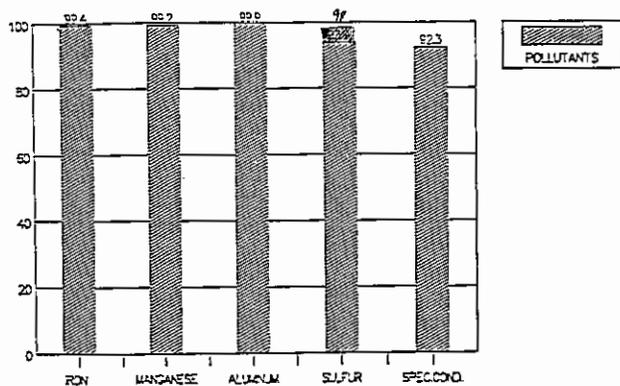
GRAPH 1

FT. HILL MINE 3/87 - 5/88



PERCENT OF POLLUTANT REMOVAL

BOILERMAKER'S POND 5/88-5/89



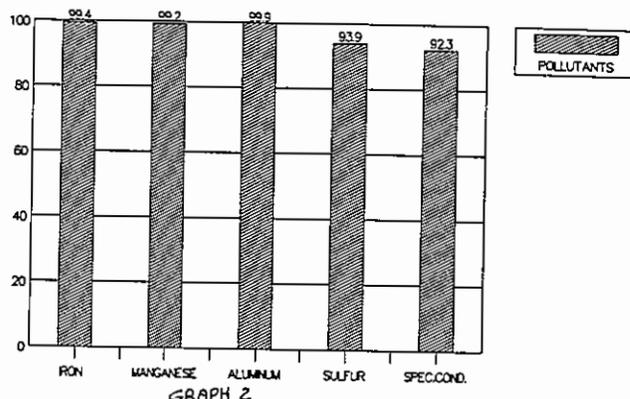
GRAPH 3

The manganese discharge was reduced by 99% at the Robin Hood site and 99% at the Ft. Hill site. 99% reduction was achieved at the stationary sites. Sulfate was reduced 94% at the Peabody site and 94% at the Ft. Hill site. 98% reduction was achieved at the stationary sites. The pH was improved 33% at the Ft. Hill site and 61% at the mine sites. Compliance was met and held at the mine sites. No N.P.E.S. compliance requirements were in force at the stationary ponds.

All of these results were achieved quickly for the scope of the site (one week for the stationary ponds, 36 days at Ft. Hill and 8 months at Robin Hood). Each one was inherently different and each responded well to bioremediation. Information on individual sites is available upon request from Lambda.

PERCENT OF POLLUTANT REMOVAL

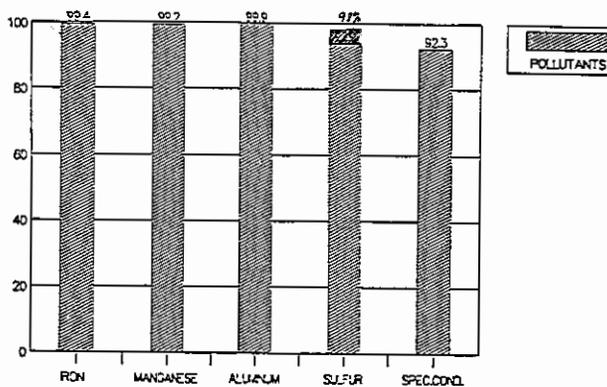
ROBIN HOOD MINE 11/88-12/89



GRAPH 2

PERCENT OF POLLUTANT REMOVAL

HICKORY CREEK POND 8/89-12/89



GRAPH 4

Summary

The Lambda technology has evolved from a random collection of microbes in a pool to a viable new BIO-CARB application. It seeks only to successfully emulate and enhance the natural microbial cleaning processes nature has employed for countless eons to insure us of having viable aquatic, marine and terrestrial ecosystems and their surrounding ecotones. Even though we are fortunate enough to reside on a planet that is 75% water, the supply of clean, fresh water is not finite, unless we assist as best we can to clean up the messes we make in supplying our other needs. Caustics, surfactants and flocculants offer their own solutions and create problems in their solving of problems. They also require continual application, often in

greater and greater amounts if they are to be continually effective. In evaluating treatment technologies, cost and effectiveness, practicality and ease of use are all important considerations. If bioremediation can offer equal effectiveness, a single application (being dumped in from a 20 gallon drum), and permanent remediation, it will surely fulfill its bright promise.

One problem is the inability to leave a system alone once it is working properly. There is a desire in many cases to make it a "little better". Tampering with the ponds, in any way, whether it be by dumping materials other than what they were designed for, changing the pond sizes, changing the water levels, etc. can disrupt the system. It will eventually rebalance itself, given time, but it will not work as effectively as it did before, until the new balance is achieved. If what you add kills the key microbes or starves the system for balanced oxygen-carbon dioxide, it could kill it. Then you have to start over.

It is a hard lesson to learn, but the old adage still applies - "If it ain't broke, don't fix it". Left to her own devices, Mother Nature will continue to provide us with clean water, fresh air and arable lands. When we "fix" things by changing the existing systems, then she needs a helping hand. Bioremediation is that helping hand and one that won't give the earth terminal indigestion.

Literature Cited

- (1) Clark, Wm. C, "Managing Planet Earth" Scientific Am. Special Issue; Sept. 1989.
- (2) Davison, Jo, "A Natural Solution to Acidic Pollution"; Mine Drainage Task Force Symposium; April, 1987.
- (3) Davison, Jo & Crawford, Jim, "The Application of the Theta IMPPS Technology for Acid Drainage Treatment", Mine Drainage Task Force Symposium; April, 1989.
- (3) Wells, Brent; Theta IMPPS Application At Robin Hood Mine, Personal Communication; December, 1989.
- (4) Hilton, Tiff; Bio-Carb Application at Leckie Smokeless Mine, Personal Communication; December, 1989.

