Bioremediation: Taking the Microbe's Perspective

Reducing Contaminant Concentrations with Bugs

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Bioremediation is rapidly becoming the remedy of choice at many contaminated sites. It seems simple: pump in oxygen, surfactants or nutrients (known as "biostimulation"), or a few microbes (known as "bioaugmentation"), or some combination and wait a few months. Sometimes there is a dramatic decrease in the contaminant concentrations. Many times the initial decrease is only temporary and the concentrations begin to rise again with time.

The Silver Bullet - The problem is often not the *remedy*, it is the *method*. Engineers and hydro-geologists who use bioremediation as only one of many remedial techniques often do not know enough about subtle microbiological mechanisms to design the best bioremediation for a given site. Often, the "silver bullet" offered by adding genetically-engineered microbes, a surfactant, or oxygen is not the answer, and this force-fitting of a remedy often does not remediate every contaminant satisfactorily.

No Walk-Away Remedy - Toxic contamination often kills much of the native ecological community. As the contamination begins to migrate from the source area, it undergoes transformations, both chemical and physical, which, as a rule, gradually reduce their concentrations. This is the basis for the "intrinsic bioremediation" or "monitored natural attenuation" remedy that is becoming so popular. Although sometimes misunderstood as a "walk-away" solution, natural attenuation instead relies on the delicately-balanced existing ecology. If not severely compromised by toxic concentrations of contaminants, the site will be able to clean itself. Under conditions of severe contamination or when a shorter timeframe is desired, Mother Nature can use some help, and an "engineered" bioremedial solution is needed. Do not confuse "engineered bioremediation" with "genetically-engineered microbes." The techniques used by. LBSI (and that continues to be used by Alpha Omega today) does not include any genetically-engineered microbes, only microbes that are already found at the site (indigenous microbes). "Engineered bioremediation" means that scientists intervene to improve upon the natural processes that break down contaminants.

Engineering a Remedy Not the Microbes - Advantages of engineered bioremediation over other types of engineered remedies are numerous, not the least of which is fewer moving parts to break down. The application of engineered bioremediation to a particular site must be evaluated by using site-specific data characterizing its geology, chemistry, and ecology. Employing an

understanding of the role of each of the hundreds of microbes that exist at a contaminated site will result in a more efficient, effective, and lower cost cleanup.

A Multi-Step Process - Once contamination enters the environment, the natural ecological system (including the microbial community) begins either to slowly adapt or is poisoned by high levels of toxic chemicals that usually exist closest to the source. Furthermore, the microbes that function best in one environment can be sluggish in another, even though both may be needed to destroy the contamination. For example, if the contamination is in an environment where oxygen is abundant, highly aerobic (oxygen-loving) microbes are probably flourishing while those that thrive in oxygen-depleted atmospheres (anaerobic) languish. However, both may be needed to complete a successful remedy, as one type of microbe usually cannot accomplish the whole job.

Phosphates - Phosphates are just one aspect to be considered when balancing ecosystems of any kind and on any job site. All projects require the balancing of phosphates in one form or another. For example, the pond, stream, river and creek projects need the phosphates to be at a level which provide that nutrient in the proper balance to nourish the aquatic micro and macro phyta. Too much phosphate causes over enrichment (eutrophication). Too little phosphate inhibits properly balanced aquatic ecosystems, due to the lack of adequate producers (green plants). The producers make food and give off oxygen through photosynthesis. The producers are the only organisms that can produce food for all of the other aquatic micro and macro organisms.

Three Principles - LBSI devised a unique process to use microbial consortia to remediate contaminated sites. (This same process continues to be used by Alpha Omega.) Often over 350 non-pathogenic bacteria, fungi, protozoa, and algae are used. The process is based on three principles: balancing the ecosystem, restoring the soil's healthy carrying capacity, and finding processes that treat both organic and inorganic contamination.

Microbial Consortia - Bioremediation using microbial consortia employs a series of complex transformations to destroy or immobilize the contaminants. Each step of the transformation process generates intermediate by-products which, in turn, must be degraded to end products of carbon dioxide and water. Many transformations require the participation of numerous and specific microbes. If these microbes are too weak to perform their roles, the destruction will be incomplete, often leaving by-products that are more toxic than the original contamination. For instance, Total Petroleum Hydrocarbon (TPH) degraders may readily transform a diesel spill into its intermediate chemical components, but these components (benzene, toluene, ethylbenzene, and xylenes) are more hazardous than the original diesel. Using only one or two microbes to destroy the contamination, or force-feeding the microbes only a single component of their diet (e.g., oxygen) may feed one set of degraders at the expense the others, causing large-scale die-off in a critical component of the microbial community. Hence, microbes needed to perform the final degradation of these intermediate toxins will languish.

A Systems Approach - For the cleanup to be achieved within a reasonable time frame without the threat of persistent, undesirable by-products, the entire system must be optimized. It has been found that Aroclor 1260, a tenacious PCB, can be effectively bioremediated by 54 individual microbes (including bacteria, fungus, protozoa, and algae) in a 35-step process. It's no wonder one or two engineered microbes can't get the job done. In addition, by using only a few microbes or a single stimulant, contaminants that are not targeted can be mobilized unintentionally. For example, treating for a single metal could mobilize other metals. The solution is to apply a consortium of microbes that employs a systems approach to the cleanup.

Acclimation- In a proprietary process, the microbes are acclimated to withstand the highest levels of contamination found at the site. These acclimated microbes are combined with a mixture of natural nutrients and become the "inoculum". The optimized microbes, as part of the inoculum, are re-introduced to the site. As the microbial community thrives, it digests, de-toxifies, or immobilizes the different chemical components in the contamination, which it uses as fuel. As this food source is consumed, the contamination concentrations decrease and the microbes die back to the population levels that existed at the site before it was contaminated, known as its "Carrying Capacity".

That's how it all works. This approach has been successfully applied at hundreds of contaminated sites around the country. Each project results in our adding more microbes and functions to our existing database of over 15,000 entries.

Thoughtful and well-engineered bioremediation that enhances and optimizes the viability of all necessary microbes will result in a successful remediation over the shortest time frame. If you would like more information on this approach, please contact us through the Alpha Omega website.

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