National Seminar On Biological Application and Environmental Friendly Protection of Malaysian Rivers

Location: **Penang, Malaysia**

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BIOREMEDIATION OF POLLUTED RIVERS, LAGOONS AND LAKES- THE MICROBE-LIFT® WAY

What Is Bio-remediation:

Biological treatment and reliance on bacteria is not new or novel; it has played a central role in conventional waste treatment throughout the history of mankind. What is new however, is our growing understanding of the natural processes and how we can utilize bacteria for industrial, agricultural and residential applications in breaking down organic waste thereby enhancing the bio-degradation process fundamental to natural recycling and sanitation clean-ups.

Bioremediation consists mainly of biostimulation, where nutrients or oxygen are added to soil or water to stimulate native bacteria a, and bioaugmentation, where select microorganisms, naturally occurring or engineered strains, are introduced to enhance the degradation process.

The primary use of biological agents has been in enhanced natural remediation and wastewater treatment of sanitation systems for residential and municipalities, lakes, rivers and ponds, once-through lagoons for agricultural and industrial activated wastewater systems. Bioremediation can usually be done in situ, without the need for existing system modification and saving large upfront capital cost in waste treatment equipment. Bioaugmentation, the purposeful inoculation of external microorganisms to a biological system with sufficient population of suitable types of bacteria will dramatically improved results where biostimulation alone has proven inadequate or ineffective. In order to understand the growing use and evolution of bioremediation, we need to understand in simple terms the biological function of bacteria (prokaryotes) and consider their role in the balance of nature.

"If there is food, some organism will eat it. If there is a place to live, some organism will live there. Every species has a great ability to produce offspring and its population expands until it runs out of food or it is limited by competition, its own waste products, or some other factor. Changes in climate or introduction of a new species from elsewhere can greatly affect the existing balance of nature."
This simple statement summarizes the interactions of all living things on Earth. Bacteria are single-cell organisms and most of them must find foods such as sugars, proteins and vitamins-nutriments to live. The various metabolic capabilities of bacteria are the key traits that we use to group and classify them into their genera/sub-species.

The ecosystem, both on land and in the water, depends heavily upon the activity of bacteria. The cycling of nutrients such as carbon, nitrogen, and sulfur is completed by their ceaseless labor. Organic carbon, in the form of dead and rotting organisms, would quickly deplete the carbon dioxide in the atmosphere if not for the activity of decomposers. This may not sound too bad to you, but realize that without carbon dioxide, there would be no photosynthesis in plants, and no food. When organisms die, the carbon contained in

their tissues becomes unavailable for most other living things. Decomposition is the breakdown of these organisms, and the release of nutrients back into the environment, and is one of the most important roles of the bacteria.

The cycling of nitrogen is another important activity of bacteria. Plants rely on nitrogen from the soil for their health and growth, and cannot acquire it from the gaseous nitrogen in the atmosphere. The primary way in which nitrogen becomes available to them is through nitrogen fixating bacteria. These bacteria convert gaseous nitrogen into nitrates or nitrites as part of their metabolism, and the resulting products are released into the environment. Some plants, such as liverworts, cycads, and legumes have taken special advantage of this process by modifying their structure to house the bacteria in their own tissues. Other denitrifying bacteria metabolize in the reverse direction, turning nitrates into nitrogen gas or nitrous oxide. When colonies of these bacteria occur on croplands, they may deplete the soil nutrients, and make it difficult for crops to grow.

Bacteria are also used in sewage treatment facilities. Solid matter, after having been separated from liquid wastes by screens and shredders, are added to a group of anaerobic prokaryotes. These bacteria decompose the material, converting it to material that can be used as landfill or fertilizer in land farming.

Bacteria are also used in solving environmental problems because of their selective capability to consume and degrade almost any compound. For instance, certain cultured bacteria are now being sprayed on oil spills and petroleum drilling lagoons, where they rapidly multiply and break down the oil molecules into less toxic compounds. In a similar way, bacteria can also clean up old mines. The water from old mines is filled with highly acidic heavy metals that are highly toxic and expensive to clean up. However, there is an increasing use of bacteria, especially a genus called Thiobacillus, which thrives in acidic water. These microbes can extract copper from the water, and other valuable metals, utilizing oxidize-sulfur to accumulate and extract the metals. These are just two examples of the ways that bacteria can be practically used to solve environmental problems, and over-time many more applications will be developed through selective breeding and mixed production of various bacteria cultures.

Basic Biological Treatment Processes Are Based on the Following Chemical Reactions:

Aerobic

$$BOD + N + P + O_2 \rightarrow CO_2 + H_2O + cells$$

Facultative

$$CO_2 + NO_3 + O_2 \rightarrow NO_3 + CO_2 + cells$$

Anaerobic

$$BOD + N + P \rightarrow CH_4 + H_2S + CO_2 + cells$$

Life Cycles

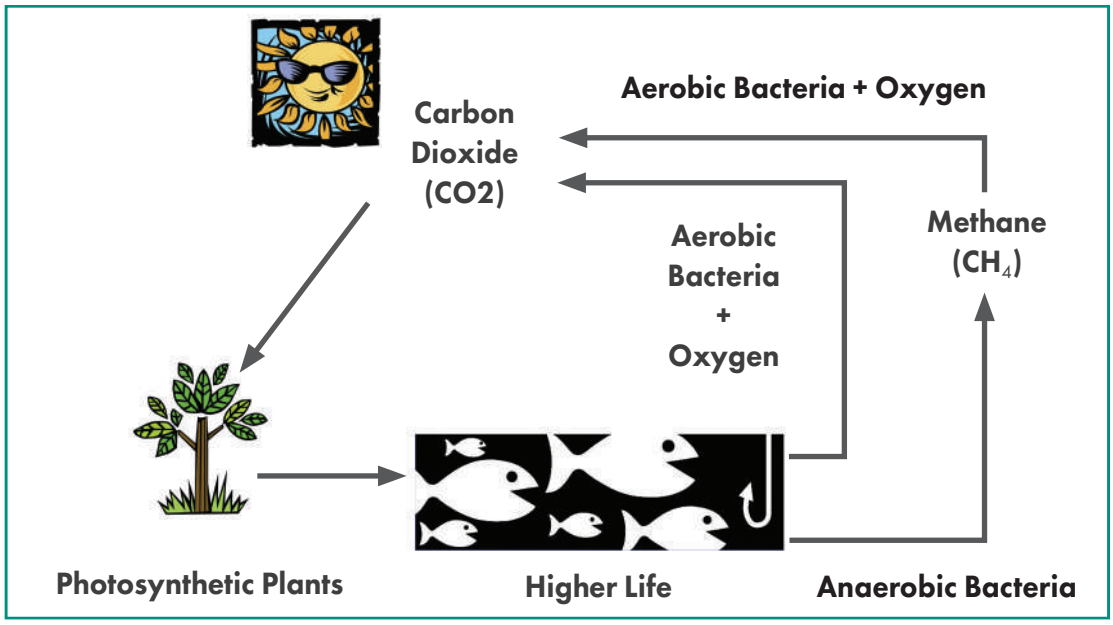

Fig 1: *The Carbon Life Cycle*

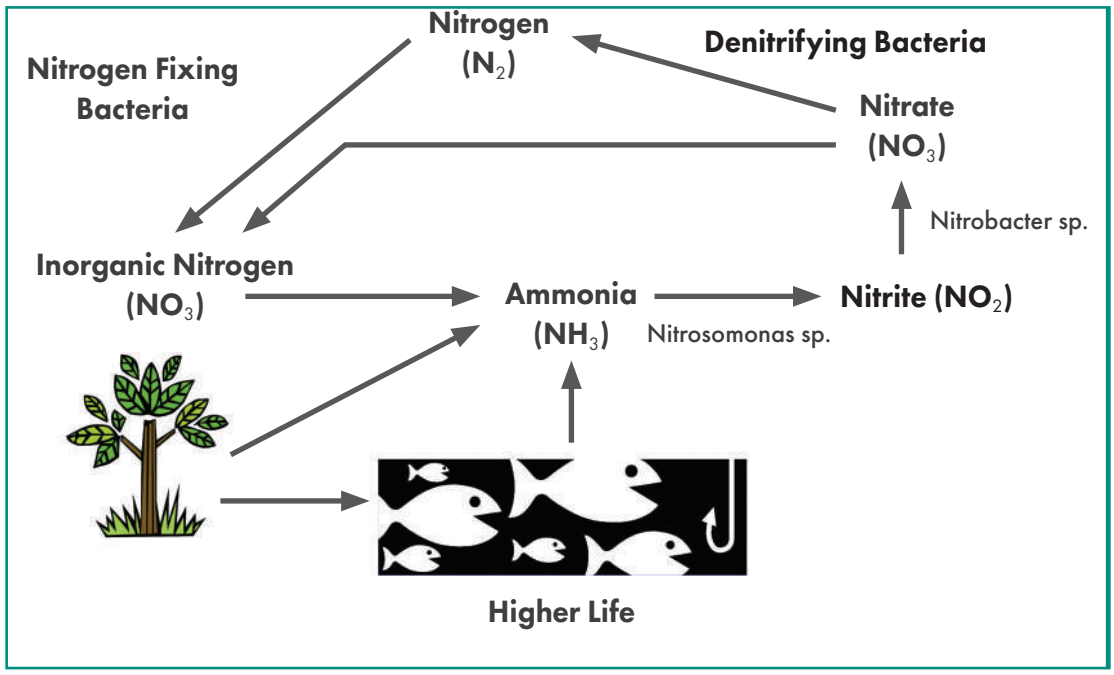

Fig 2: *The Nitrogen Life Cycle*

Bioremediation Operates on the Simplified Kinetic Model Below:

$$S_e = \frac{S_i}{1 + Xc\ Ks\ \Psi h}$$

Where	S_e	-	**effluent concentrations of substrate**
	S_i	-	**influent concentrations of substrate**
	X_c	-	**cell mass in gm/L**
	K_s	-	**specific rate coefficient, gms/L ***
	day Ψh	-	**hydraulic residence time, days**

Fig 3: *Simplified Kinetic Model*

A successful bioremediation therefore require an adequate concentration of balance types of micro-organisms in the wastewater with appropriate pH and temperature to be treated for a sufficient amount of time for bacteria to multiply.

Augmentation Chemistry Vs. Stoichiometric Chemistry

Many engineers and operators are accustomed to having precise application information when using chemical products in chemical process systems. This is usually not the case with biological systems and biological products used in bioremediation process.

The reason for this is quite simple. Chemicals are non-living things and act in predictable stoichiometric ratios based on molecule for molecule interactions. A good example is pH, which is the measure of [H+] ions or [OH-] radicals in solution. To neutralize a solution which is either too acidic or too alkaline requires the addition of the reciprocal ions or radicals that combine in a direct one to one ratio to form water. For example, if a solution of hydrochloric acid, HCl, is added to an alkaline solution of sodium hydroxide, NaOH, the [H+] ions and [OH-] radicals will react to form water with the residual ions to form salt (NaCl) in a predictable, quantifiable reaction.

In biological systems, the dynamics are biochemical as opposed to chemical, and the active agents are living entities. Where one would have to increase the quantity of chemical proportionally to deal with a higher load of reactant, in a biological system the biological additive can grow to help compensate for increased loadings. While small increases in dosage may be required with increased loading, proportional increases are not required. The organisms grow in response to higher loads, so that the benefit is multiplied which makes biological additives much more cost effective than chemical additives. It also makes for dosage programs that do not seem to properly compensate for loading changes, as bacteria has an inherent ability to adjust to loading changes.

Bio-augmentation dosage programs typically follow a descending application schedule to accommodate the fact that the benefits of the addition are multiplied. These programs usually involve a "purge" or "inoculation" dosage to establish the required bacteria population quickly.

The "purge" or "inoculation" is followed by an intermediate maintenance dosage to support the development of the required population. Finally, a regular maintenance addition is used to maintain the required population to maintain the biochemical improvements, which have been realized through the "inoculatiom" and "intermediate maintenance" dosages.

On occasion, when a biological system experiences shock loads, either hydraulic or organic, it may be necessary to return to the "intermediate maintenance" dosages for a week or two to fortify and stabilize the bacteria population.

MICROBE-LIFT® Remediation Technique

MICROBE-LIFT® technology has proven to be one of the most successful bio-product to be used in Bioaugmentation for a broad spectrum of polluted bodies of water and various waste treatment systems. MICROBE-LIFT® technology is a combination of over 30 species of naturally occurring live bacteria suspended in a liquid medium used for the treatment of industrial, agricultural and residential organically contaminated wastewater. It is a product with high cell mass and specific coefficient.

MICROBE-LIFT® technology was developed in 1976 by **Ecological Laboratories** in the United States. With almost three decades of experience in bacteria culture selection and bio-product formulation, **Ecological Labs** has become one of the world's leading providers of live bacteria formulas for wastewater management. Over the years, their direct involvement in microbial treatment development and planning has lead to successful application programs for a broad spectrum of industrial, municipal and residential wastewater problems.

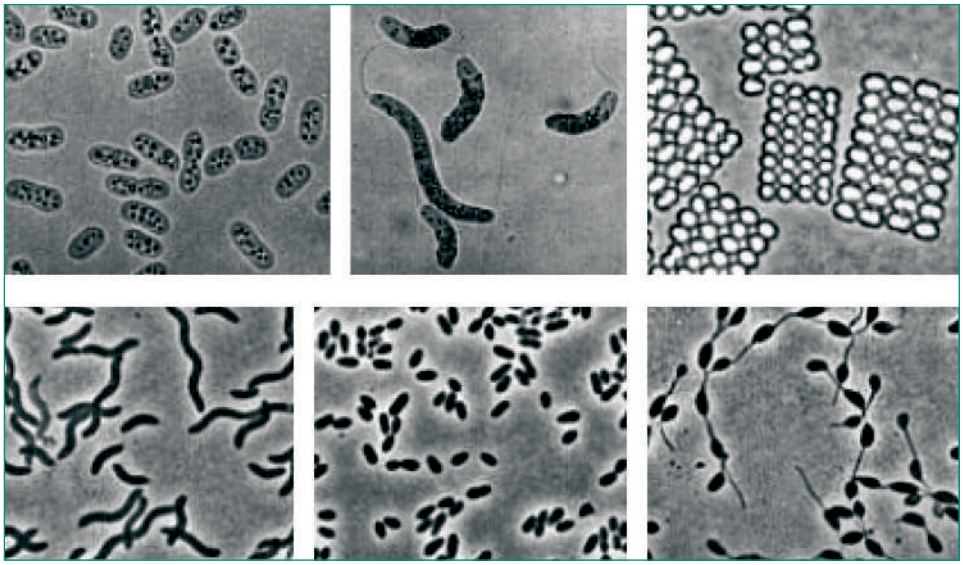

Fig 3: ***MICROBE-LIFT®*** *technology type of bacteria*

MICROBE-LIFT® bacterial culture contains aerobic and anaerobic species as well as chemo- and photo-synthetic stains. The microorganisms in MICROBE-LIFT® technology are natural occurring, non-toxic and non-pathogenic. They are living bacteria, held in a state of suspended animation in a liquid medium. The product formulas are not harmful to humans, animals, plants and all types of aqua culture. When MICROBE-LIFT® is added to a contaminated area, the bacteria immediately revive themselves and begin to feed, reproduce and attack that organic waste.

Areas of Application

The following are *Before and After* pictures of MICROBE-LIFT® treatment programs from around the world. Once you see them, you will want to know more about how the MICROBE-LIFT® method of bioaugmentation can help you and your community.

A Swine Production Waste Pond before Treatment

The same pond after 5 weeks of Treatment with Microbe-Lift® technology.

Domestic Sewerage Pond in Uruguay before Treatment

Domestic Sewerage Pond in Uruguay 72 days after Treatment with Microbe-Lift® technology.

A beautifully landscaped pond at the Sheraton Tower in Singapore was turbid with fishy smell.

After 6 months the water was very clear at the Sheraton Tower Hotel in Singapore using Microbe-Lift® technology.

Grease Trap Pond in Panama-2002 Entire Lagoon was covered with oil, grease and solid

Grease Trap Pond in Panama- 72 days after Treatment with Microbe-Lift® technology

MICROBE-LIFT® Technology Has Proven to Be Excellent In A Broad Range of Applications Utilizing Bio-Augmentation and Remediation:

1. Achieving ecological balance of natural bodies of water such as polluted lakes and lagoons, while reducing insect population.
2. Economical treatment of agricultural wastewater using simple oxidation ponds for swine, dairy, poultry and duck farms. Treated effluent has proven to improve fertilizer value as added benefit.
3. Enhancing the effectiveness of municipal and industrial wastewater treatment plants; increasing the operation efficiency and capacity by reducing COD, BOD, TSS, sludge and bad odor. The economic rewards reduce maintenance costs; lower capital expense and penalty charges.
4. Improving water quality in commercial fresh water shrimp and fish farming lagoons, reducing mortality rate and increasing yield and quality.
5. Commercial grease trap treatment of restaurant and hotels drastically reduces the cost for fat and grease removal and eliminates bad odors.
6. Rejuvenating failing leach fields and septic tanks reducing the need for expensive system removal and replacement, while eliminating odor.
7. Improving the ornamental pond water quality and significantly reducing the need for filter cleaning and maintenance.
8. Rapidly breaking down hydrocarbon pollution from oil spills and production ponds, as well as removal of hydrogen-sulfates helping to prevent tank corrosion.

Systems Program Approach

We provide total solutions and technical support to solve your water pollution and waste treatment problems by developing:

Innovative Treatment Plans

Identifying problems, establishing goals and defining criteria for success: we work with you to review your needs via systematic survey forms.

Sustainable Natural Solution

Providing environmental friendly treatment solutions to achieve ecological balanced system through natural microbial remediation and bioaugmentation technology. We maintain close technical support to review results and provide adjustments in order to continue sustainable long-term performance.

Cost Effective and Efficient

Natural solutions that in most cases are far more effective and efficient than chemical and mechanical methods, usually reducing the need for high upfront capital equipment investment.

Environmentally Safe

MICROBE-LIFT® technology uses only naturally occurring non-toxic and non-pathogenic bacteria based products that are safe for humans, animals and aquatic life. Formulated and manufactured in our state of the art laboratory under strict quality control guidelines in a contamination free environment.

Case Studies From Typical Applications Include:

1) Xiba River, Kunming Trial Project

Xiba River Project was a very interesting study of remediation in an open body of flowing water. Traditionally this type of problem has been extremely difficult to effectively treat, and many had failed in this effort. The Trial Project required that we develop a novel and unique application system, but utilized the basic principles of bio-remediation, and in the end we were able to provide a very cost efficient solution.

The Xiba River is an extremely polluted river flowing 4 km through Kunming, China. The river has an average flow rate of 26,000 m3 per day. The water is badly polluted from industrial, commercial and domestic waste. It had a grayish color, high turbidity, pungent odor and toxic effect had virtually eliminated signs of aquatic life.

The Pilot Study using MICROBE-LIFT® technology was carried out in the river's last 1.5km treating this section of the river as a plug flow reactor. The trial was carried out from Nov 2004 to March 2005 in collaboration with Kunming Technical University. The Project successfully demonstrates the efficacy of MICROBE-LIFT® bioaugmentation in an open river.

Measuring various water quality parameters along the river's pathway before and after treatment, the Environmental Graduate Students monitored the effects of MICROBE-LIFT® technology during the trial. The Project conclusively demonstrated MICROBE-LIFT® technology's ability to restore the polluted river to an ecologically balanced environment. Aquatic life returned to the River which also demonstrated MICROBE-LIFT® technology's non-toxicity to aquatic life; the odor was eliminated, water clarity was improved, and general health of the waterway was restored. MICROBE-LIFT® technology proved to be a cost effective, environmentally friendly, natural method of rehabilitation.

The various water parameters measured (such as COD, BOD, TSS, Total Nitrogen and Total Phosphate) were reduced by about 50% at monitoring station 1.4 km downstream from the point of inoculation. The average remediation (effective retention) time for 1.4km length was about 7 hours. Kunming Technical University is convinced that a much higher rate of degradation is achievable based on a complete river treatment that would significantly raises the effective retention time for the MICROBE-LIFT® treatment. The basic Kinetic Model for bio-remediation is built upon the effective rate of the selected bacteria to degrade the specific pollutants, the number of bacteria available, and the time allowed for the bacteria to interact on the pollutants. While pH, temperature, sunlight and other limiting factors will affect the results, the basic Kinetic Model is the primary focus for treatment.

The Xiba River posed a set of very challenging problems to overcome, retention time being the most difficult. Yet by developing a novel and inexpensive Bio-Media, we were able to increase the surface area and provide the treatment needed.

2) Pilot Study on Piggery Wastes Treatment at Poh Huat Pig Farm, Sarawak, Malaysia.

Searching for an effective, environmentally friendly method of treating animal farm wastewater, a pilot project was commissioned in collaboration with National Resource and Environment Board (NREB) of Sawarak in March 2004 at Poh Huat Pig Farm. The Project goal was to assess and confirm the results of MICROBE-LIFT® treatment in reducing BOD and COD in piggery waste. This is an area where MICROBE-LIFT® technology has been very successful in similar studies in the USA, Korea and Northern Europe.

The result of this Pilot Project confirmed that MICROBE-LIFT® technology would produce the same successful results in Malaysia. Characteristically, MICROBE-LIFT® 's bioremediation eliminated bad odors within one week after treatment, with significant reduction in COD and BOD. Over the next three weeks, as the bacteria began to breakup the organic sludge at the bottom of the pond, MICROBE-LIFT® technology again demonstrated its effectiveness in degrading hardened organic sludge built up over the years in an open waste lagoon. Once all the organic sludge has been degraded, the pond will achieve its ecological balance and help to maintain a clean environment.

Fig 5: *Pond Condition Before and After Treatment at Poh Huat Piggery Waste Treatment*

3) MICROBE-LIFT® Treatment to Sheraton Tower, Singapore Landscape Pond, Singpore

Sheraton Tower Hotel, Singapore has a 100 m beautifully landscaped pond for display of koi fish. There were two small sand filters and no biological filters in place. The water was turbid with high COD and BOD, as well as a bad fishy smell. MICROBE-LIFT® remediation method was introduced to obtain and maintain a clean and ecological balance for this pond environment without the need for an elaborate and expensive biological filter.

4) Mosquito Larvicidal Evaluation by Insect Control & Research Inc., Baltimore, USA

MICROBE-LIFT® technology was evaluated for its potential as a killing agent against the aquatic stages of laboratory-reared Aedes aegypti. The efficacy of the bacteria product was assessed for its affect upon the egg stage, the larval stages, the pupal stage and the resulting emergence of adults.

5) Use of AquaClean in Freshwater Shrimp Production, Mississippi

Mississippi Gulf Coast Community College in Southeastern United States conducted an evaluation on MICROBE-LIFT® effect in the production of Macrobrachium Rosenbergii fresh water shrimp production in 2001.

The study indicates that MICROBE-LIFT® technology increases total production and average size of shrimp while improving the feed conversion and reducing production cost.

Benefits of MICROBE-LIFT®

- Total Shrimp Production: +17.4%
- Total Feed Consumption: -14.4%
- Total Weight per Shrimp: +22.4%

[A copy of the full report can be read in Case Study 12104]

Further detail on Bioremediation and MICROBE-LIFT® technology is also available at **www.EcologicalLabs.com**

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