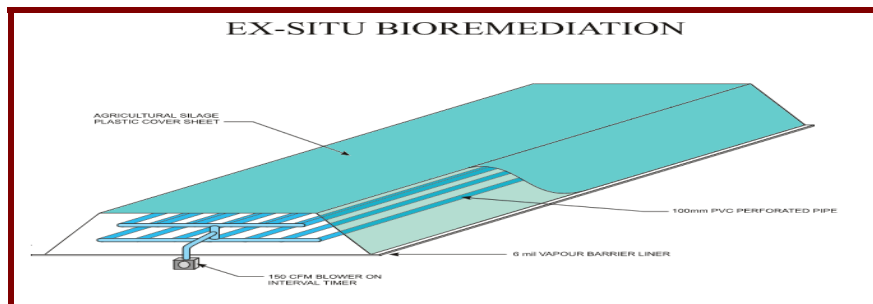


Surfactant Enhanced Bioremediation (SEB)

Surfactant Enhanced Bioremediation (SEB[®]) using Ivey-sol[®] involve the use of Ivey-sol formulations which are patented non-ionic surfactant mixtures used in the in-situ and ex-situ treatment of petroleum hydrocarbons, heavy metals, and more recently radioactive type contaminated waste. These surfactant formulations have the ability to enhance soil biodegradation.

During In-situ and Ex-situ Bioremediation, the effectiveness of the bioremediation process is a function of balancing several physical and chemical parameters to achieve effective bio-mineralization of the target contaminants. The addition of Ivey-sol[®] to the substrate can aid in the controlled de-sorption of the contaminants making them more bio-available. As a result, the duration for of hydrophobic organic chemicals (HOC) bioremediation can be reduced by as much as 40 to 60%, or more.



Normally hydrophobic organic chemicals (HOC) exhibit limited bioavailability to microorganisms as the contaminants tend to partition onto the soil matrix. This partitioning can account for as much as 95% or more of the total contaminant mass. Thus this limits the concentration of HOC available to the microbial population. Hence certain HOC's such a Polycyclic Aromatic Hydrocarbons (PAH) and Phtalates can persist in the soil matrix for long periods of time. The use of Ivey-sol surfactant formulations, as part of a well designed bioremediation process, will provide a mechanism to mobilize the target contaminants from the soil surface to make them more available to the microbial population.

Bioavailability is governed by the substrate concentration that the cell membrane comes in contact with (i.e., what the microorganisms 'see') as well as the rate of mass transfer from potentially bioavailable (e.g., non-aqueous HOC's) phase to the directly bioavailable (e.g., surfactant-aqueous HOC) phase. SEB affects the sorption of HOC and surfactants at the solid-liquid interface (i.e., the surface-H₂O-NAPL interface). This mechanism is in-part responsible for the increased bioavailability of the HOC and surface-bound nutrients. SEB using Ivey-sol is effective at low surfactant concentrations. It expedites bioremediation of the contaminated soil and positively affects the surfactant-soil-NAPL systems (e.g., mass transfer of HOCs, cell hydrophobicity, and cell attachment at interfaces) while averting the inhibiting and/or microbial toxic effects associated with some surfactants (i.e., cationic and anionic) which are only effective at much higher concentrations. The SEB mechanisms by which Ivey-sol surfactants influence these processes is illustrated below.

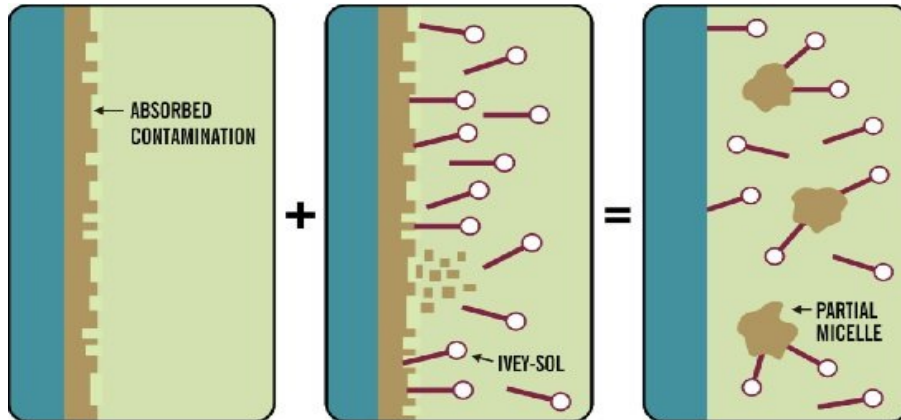
Ivey-sol Technology (How It Works)

An illustration of how the SEB - Ivey-sol technology works, (i.e., the mechanism) has been illustrated below. This should be used to augment a companies present knowledge of bioremediation to appreciate the Ivey-sol surfactants effects on a microscopic scale in improving the controlled liberation of hydrocarbons and nutrients (i.e., surfactant-aqueous HOC's and nutrients-aqueous) and their controlled availability for mineralization by the microorganisms present.

This mechanism can be described as follows:

- i) When HOC (i.e., petroleum product) is absorbed on a soil grain, water alone will not remove it from the surface. This is a function of the hydrophobic characteristics of the HOC, which repels the water at its surface and its inherent low water solubility.
- ii) With the addition of SEB Ivey-sol surfactants, the Ivey-sol hydrophobic grouping is repelled by the water but attracted to the HOC on the surface. At the same time, the Ivey-sol hydrophilic grouping is attracted to the water molecules.
- iii) These opposing forces loosen the HOC from the surface of the soil matrix and suspend it in the water phase. Once dissolved, the suspended HOC is more visible to the microbial population present.
- iv) Once liberated in low concentration in a 'surfactant-aqueous HOC' microscopic outward appearance, it is more bioavailable to the microbial population.

This illustration demonstrates how the Ivey-sol Technology desorbs the contamination of the soil and either dissolves it for In-situ or Ex-situ applications. In the case of Ex-situ Surfactant Enhanced Bioremediation (SEB), the surfactants desorb the contaminants making them more Bio-Available and as a result expedite the biodegradation process.



Range of Application

As the image below indicates, Ivey-sol surfactants formulation can selectively dissolve a broad range of petroleum hydrocarbon from light, to medium, to heavy-end HOC type contamination. In addition, Ivey-sol formulations have also been developed that are very effective on: Chlorinated Solvents, PCB's, PAH's, and MTBE.



Ivey-sol, have proven to enhance the effectiveness of In-situ soil and groundwater bioremediation, and Ex-situ soil (land-farm) type bioremediation processes by increasing HOC bioavailability accordingly.

Client Affidavit:

“After excavation and bio-piling of the soil, the surfactant enhanced bioremediation (SEB) treatment was applied and the bio-pile was covered. Daily aeration was done during the treatment period. After only 12 weeks samples were taken from the bio-pile showing that the remediation of the fuel-oil and PAH contamination was completed to the BC Environmental Standards and safe for reuse on-site”

Quinsam Coal Corporation

Awards & Nominations

In March 2005, Ivey International Inc. was Nominated for a National GLOBE Award for Corporate Innovation and Application. In October of 2004, Ivey International Inc. was a Finalist for a National CUI Environmental Brownfield Award.

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