

## Special Article - Environmental Microbiology

# *In-situ* Bioremediation

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## Editorial

Bioremediation is the use of microorganisms, plants or biological enzymes to achieve hazardous waste treatment. The treatment can focus on different types of media with different possible targets. *In situ* bioremediation, bioremediation in the subsurface layer is easily accessible to the environment in comparison with *ex situ* bioremediation. *In situ* bioremediation can be applied in an unsaturated / vadoze zone or in saturated soils and groundwater.

*In situ* bioremediation technology was originally developed as a less costly and more efficient alternative to standard pumping and treatment methods used to clean waterborne and soil contaminated with organic chemicals but has since been extended to toxic metals. *In situ* bioremediation has the potential to offer benefits, such as the complete destruction of contaminants, a lower risk for employees in the workplace and lower equipment / operating costs.

One way of classifying *In-situ* bioremediation is the type of metabolism. Two categories of high-level metabolism are aerobic and anaerobic. Target metabolism for *In-situ* bioremediation will depend on pollutants of interest. Some contaminants decompose in an aerobic way, some are anaerobic and some pollutants can be biodegradable under aerobic or anaerobic conditions.

Another way to classify *In-situ* bioremediations is the degree of human intervention. Accelerated *in situ* bioremediation is located at one end of the scale where there is a high degree of human intervention. With accelerated *In-situ* bioremediations, substrates or nutrients are added to the underground to stimulate the growth of a targeted consortium of bacteria. Usually, target bacteria are natural, but enriched bacteria cultures that are very effective in degrading a particular contaminant can be introduced into a waterborne layer, which is called bioaugmentation. Accelerated *In situ* bioremediation is used where it is desirable to increase the rate of biotransformation of contaminants, which may be limited by the lack of required nutrients, electron donor or electron acceptor. The type of adaptation required depends on the target metabolism for that pollutant. Aerobic *In situ* bioremediation may only require oxygen as an electron acceptor, whereas an anaerobic *In-situ* bioremediation generally requires the addition of an electron donor and possibly an electron acceptor. Particularly chlorinated solvents often require the addition of carbon substrate to stimulate reductive dechlorination. The purpose of accelerated *In-situ* bioremediation is to increase

biomass by contaminating the volume of the aquifer layer, thereby achieving effective biological degradation of dissolved and adsorbed contaminants.

On the other side of the scale, the natural attenuation is the method of using bioremediation *in situ* without substantial human intervention. Natural attenuation is a versatile approach, the only component is the breakdown / transformation of contaminants by household micro-organisms without human intervention. Site characterization, Natural attenuation's potential assessment and long-term monitoring include activities needed to implement Natural attenuations location characterization determines the degree of pollution, the characteristics of the scale, the geochemistry of the aquifer and the nature of the biological reactions in the aquifer. This characterization information can then be used to determine the potential for natural attenuation to prevent the accumulation of contaminating matter from the receptors in question. Analytical and / or numerical models can be used to estimate the fate of contaminants as a single line of evidence to support natural attenuation. Prolonged observation is used to assess the fate and transport of contaminants compared to predictions. Assessment can go through multiple repetitions because more data is collected and the system is better understood.

Whether an accelerated *In-situ* bioremediation or natural attenuation is used in a particular location depends on the properties of the subsurface, chemical concentrations, the objectives of the project development and the economics of each option. The rate of degradation of contaminants is typically slower in the natural attenuation scenario than in active bioremediation, because the concentration of bacteria is much greater in accelerated bioremediation and the rate of activity is proportional to the amount of biomass. Natural weakening usually takes longer. Accelerated *In-situ* bioremediations generally offer faster solutions, but have invested much more in materials, equipment and labor.

## Advantages

1. Organic pollutants can be converted to completely harmless substances.
2. Accelerated *in-situ* bioremediation can provide volumetric treatment where both dissolved and sorbent contaminants are treated.
3. Treating underground *in situ* with accelerated bioremediation can often be faster than pumping and handling processes.
4. *In situ* bioremediation often costs less than other recovery opportunities.
5. The Bioremediation Forum's treatment area may be larger than other repair techniques as the treatment moves by the tire and can reach areas that otherwise were unavailable.

6. *In situ* (vs *ex situ*) technology usually produces small secondary waste

7. *In-situ* (vs. *ex situ*) technology reduces the permeability of pollutants by different means

8. *In situ* (vs. *ex situ*) technology reduces human exposure to contaminated materials

## Disadvantages

1. Depending on certain locations, some impurities may not completely change into harmless products.

2. If biotransformation stops in the intermediate compound, the intermediate may be more toxic and / or more mobile than the starting compound.

3. Some pollutants cannot be biodegradable.

4. If not used properly, the injection molds may be clogged with abundant microbial growth caused by the addition of nutrients, electron donor and / or electron recipients.

5. Accelerated *in situ* bioremediation is based on the distribution of appropriate changes, so it may be difficult to implement completely in low permeability or heterogeneous waterfalls.

6. Heavy metals and toxic concentrations of organic compounds can inhibit the activity of the original microorganisms.

7. *In situ* bioremediation requires a population of a normally adapted microorganism that may not develop with recent leakage or gloomy compounds.