RemActiv™

Bioremediation Enhancer

Technical Specification

July 2011

The Bioremediation Process

Bioremediation generally refers to the use of microbes (bacteria and fungi) to remove toxic pollutants from contaminated soil and water.

Microbes degrade organic pollutants by breaking down (oxidizing) the chemical bonds in the pollutants in the presence of oxygen to form harmless by-products such as carbon dioxide, water and biomass.

The degradation rate of organic pollutants during bioremediation is directly related to the microbial growth conditions. There are four simple things the microbes need for optimal growth and performance:

- Oxygen – bioremediation is normally performed under aerobic conditions (anaerobic microbes also degrade pollutants but at a much slower rate) – an adequate supply of oxygen throughout the waste or soil being treated is often the limiting step for effective degradation;
- Nutrients – macro nutrients (e.g. nitrogen) and micro nutrients (e.g. iron) are both essential for microbial growth;
- Carbon Source – aerobic microbes require a source of 'energy' to grow – if this energy source is restricted to the carbon in the organic pollutants it 'forces' the microbes to preferentially degrade the pollutants;
- Water – adequate moisture is critical for effective bioremediation but is often overlooked.

Bioremediation is a particularly attractive treatment option for the removal of organic contaminants such as petroleum hydrocarbons because it is:

- Cost Effective – bioremediation is cheaper than other thermal and physical treatment processes because it harnesses the power of natural micro-organisms;
- Environmentally Friendly - organic contaminants are converted by microbes to harmless by-products such as carbon dioxide, water and biomass;
- Amenable to Biological Degradation – microbes find it easier to use petroleum hydrocarbons as a food source than other more complex pollutants;

- Low Carbon Footprint – the process has a lower carbon footprint than alternative thermal and physical and chemical processes.

Bioremediation is naturally a relatively slow process but this can be accelerated for commercial applications using the following methods:

- Bioaugmentation – the addition of microbes to the waste that have been selected based on their known ability to break down the pollutant of interest;
- Biostimulation – the stimulation of the existing indigenous microbial population in the waste through the addition of nutrients and other amendments to optimize the conditions for microbial growth. Often there are microbes already present in the waste or soil that have evolved the ability to break down the pollutants of interest but their natural source of nutrients has been depleted (e.g. at historical contaminated sites).

Many commercial bioremediation systems are not performed under optimal conditions and either take longer than intended to achieve the desired level of pollutant degradation, or fail altogether.

Most of these systems use off-the-shelf commodity products such as urea and triple-superphosphate as the nutrient source to achieve biostimulation. This is part of the problem - these products are designed as slow release fertilisers to assist plant growth and are not ideal for optimising microbial growth. Furthermore, the additional supply of micro-nutrients to ensure rapid and sustained microbial growth is generally ignored in these systems.

There is a market need for a rapid and reliable bioremediation product that is specifically designed to optimise microbial growth and hence pollutant degradation – RemActiv™ is designed to fill this market need.

The RemActiv™ Solution

After years of testing commercial bioremediation products that were impractical, expensive and had little or no effect on pollutant degradation rates, Ziltek's PhD qualified microbiologists and field staff wanted to offer the market a reliable and effective product based on sound scientific principles – this led to the development of RemActiv™.

RemActiv™ Ingredients

The main ingredients of RemActiv™ are:

- Highly available macro-nutrients (NPK) and micro-nutrients for optimal microbial growth;
- A microbial consortium including both bacteria and fungi specifically designed for the breakdown of organic pollutants.

Nutrients

The nutrients in RemActiv™ are designed to meet the specific requirements of microbial growth, not plant growth like some other commercial bioremediation products.

The concentrations and ratios of the various nutrients in RemActiv™ enable the microbes to preferentially use the organic pollutants as a carbon source.

All of the RemActiv™ nutrients are also presented in a soluble form that makes them immediately available to the microbes – this ensures a rapid start to pollutant degradation with no significant lag phase.

The nutrients in RemActiv™ not only support the growth of the microbial consortium within the product, but also stimulate the growth of indigenous microbes already present in the soil, waste or wastewater being treated. Indigenous microbes have often evolved contaminant specific metabolic capabilities leading to more rapid degradation rates following nutrient supply.

A summary of the nutrient content of RemActiv™ is shown in Table 1 below.

Table 1. Nutrient content of RemActiv™ concentrate.

Nutrient	% (w/v)
Nitrogen (as ammonium nitrate)	20
Phosphorus	2
Potassium	1
Sulphur	2.4
Zinc	0.5
Calcium	0.4
Manganese	0.4
Magnesium	0.4
Iron	0.1
Other minor trace elements	<0.1

Microbial Consortium

The microbial consortium within RemActiv™ has been isolated from contaminated industrial sites – over time these microbes have selectively evolved a specific metabolic capability to degrade complex organic pollutants including petroleum hydrocarbons and aromatic hydrocarbons such as BTEX, PAHs and phenols.

Organic pollutants can sometimes become so tightly bound to the waste particle surfaces that they are not easily accessible for microbial degradation - they are not “bioavailable”.

There are commercially available surfactants and enzymes that can be added to “pull” the pollutants off the waste particles but these are relatively costly and are often not totally effective.

The RemActiv™ microbial consortium produces bio-surfactants and extracellular enzymes naturally during the growth phase with the following benefits:

- Reduces the reliance on costly surfactant products;
- Ensures that the bio-surfactants and extracellular enzymes are evenly distributed throughout the waste to act fast where they are needed the most;
- Ensures a constant supply of the bio-surfactants and extracellular enzymes.

RemActiv™ Use and Application

RemActiv™ can be delivered in 20L plastic containers or 1,000L IBCs. It is supplied as a liquid concentrate which requires dilution with non-chlorinated water. The dilution rate depends on the application (see below).

If non-chlorinated water cannot be accessed, then de-chlorinate water by leaving it exposed to the sun for 24 hours or add sodium thiosulphate (Hypo) to the water at a rate of 1mL of a 10% solution of sodium thiosulphate per litre of water.

The application rate of the diluted RemActiv™ depends on the contaminated substrate being treated, (e.g. soil, sludge or water) – as well as the type of bioremediation system being employed (e.g. land farm, biopile, or water treatment).

The success of the RemActiv™ product also requires adequate moisture and oxygen content to be maintained.

For soil and waste applications, a moisture level where it is 'moist to the touch' is fine which can be tested by taking a handful of soil and squeezing it together. It is too wet if there is excess water running out of the soil and too dry if the soil breaks apart when reopening the hand.

Oxygen levels need to be maintained to ensure aerobic conditions are maintained. In bioremediation systems where organic contaminants are being rapidly metabolised, carbon dioxide is generated in relatively large volumes and can quickly displace oxygen. Therefore gas exchange needs to occur on a regular basis. How this is done is detailed below depending on the bioremediation system used.

Other parameters to consider are pH, temperature, and the possible presence of other chemical compounds that may be toxic to microbial growth (e.g. arsenic, mercury).

The pH range should ideally be between pH 6 and pH 9 for both soil and water treatment systems and the temperature should ideally be above 15^0C for optimal degradation. Lower temperatures may still enable microbial degradation to occur, but generally at a much slower rate.

Soil - Land farming

Land farm applications usually involve a relatively large area of petroleum hydrocarbon contaminated soil spread out to a maximum depth of around 300mm. At this nominal depth, it is assumed that gas exchange within the land farm will be such that adequate oxygen levels are maintained for aerobic microbial growth.

Once the land farm has been established, RemActiv™ can be applied as follows:

1. Shake or stir RemActiv™ liquid concentrate containers prior to dilution.
2. Dilute with non-chlorinated water in a ratio of 1:20 by volume i.e. 1 part RemActiv™ plus 19 parts water.
3. Apply the diluted RemActiv™ solution to the contaminated soil at a rate of 1L per 10 square meters as evenly as possible. This can be done using either water carts, pumps attached to IBCs using hoses, or through other tank and pump systems.
4. Periodically (ideally every 2 weeks), work the soil (tilling) to increase homogeneity and increase oxygen content and apply water if moisture levels decrease.
5. Reapply RemActiv™ at least three times to the land farm over a 6 month period at the same dosage rate as above.

Soil - Biopiles

Biopiles are a more highly engineered approach to bioremediation of contaminated soil where the soil is mixed with various amendments and then formed into a trapezoid or windrow shape. Biopiles can be formed using specially designed soil mixing equipment such as the Komatsu Reterra or the Hitachi Soil Blender, or using standard earth moving equipment such as front end loaders and excavators.

The biopile can be aerated via a network of perforated pipes that “blow” or “suck” air through the pile using pumps or can be aerated by regular turning using a windrow turner or standard earthmoving equipment.

The advantage of the biopile approach is that it has a smaller footprint than a land farm and is easier to monitor and control. The ability to adjust oxygen levels helps to ensure a faster remediation process and can even assist to control temperature and odour production. Moisture levels can either be controlled via irrigation systems or manually watered from tank systems or water carts.

The application of RemActiv™ in these systems can occur in a number of stages depending on how the biopile system is set up. However, RemActiv™ should always be included in the starting mix to ensure that degradation of the organic pollutants starts as soon as possible.

Once the biopile system has been well established, RemActiv™ can be applied as follows:

1. Shake or stir RemActiv™ liquid concentrate containers prior to dilution.
2. Dilute with non-chlorinated water in a ratio of 1:20 by volume i.e. 1 part RemActiv™ plus 19 parts water.
3. Apply the RemActiv™ diluted solution to the contaminated soil at a rate of between 10L to 50L of solution per tonne of soil (equivalent to around 1 cubic metre of soil once excavated). Variations in addition rates depend on water holding capacity of varying soil types. Application can occur via either the spray manifold of specialized soil mixing equipment, or from manual spraying using water carts, pumps attached to IBCs using hoses, or through other tank and pump systems.
4. Depending on the organic pollutant concentration and the end targets, reapply RemActiv™ solution at the same rate every 1 to 2 months until the contaminant target is reached.

Water Treatment, ***

The application of RemActiv™ to aquatic systems needs to be constantly monitored, both visually and chemically. The following stepwise process can be used to apply RemActiv™ to treat contaminated water*:

1. Remove free oil from water with absorbent booms or pads.
2. Shake or stir RemActiv™ liquid concentrate containers prior to dilution.
3. Dilute with non-chlorinated water in a ratio of 1:20 by volume i.e. 1 part RemActiv™ plus 19 parts water.
4. Spray or add RemActiv™ solution to the contaminated water. Use approximately 10L of the diluted solution to treat 1,000 litres of contaminated water.
5. Repeat the application weekly for a period of three weeks (dependent on the level of pollutant) or until the end targets are met. Repeat doses can be reduced by 50%.

* Do not attempt to treat contaminated water or groundwater that is moving off-site to another property.

** Always seek professional advice from suitably qualified consultants when treating contaminated water or groundwater because regulations will vary from state to state.

Safe Handling and Storage

Gloves and eye protection (goggles) are required to be used at all times.

If any RemActiv™ comes into contact with the skin or eyes, please rinse liberally with clean water. An MSDS is attached for further safety information.

Storage of RemActiv™ should be in a shaded area preferably below 30^0C. However, RemActiv™ has been specially formulated to maximise product stability in a range of conditions over a long period of time.

Once RemActiv™ concentrate has been mixed with non-chlorinated water, it should be used within 24 hours.

Further Information

For further information please contact the Ziltek team on:

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