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Soil Remediation

Opportunities for the use of Recycled Organics in the Bioremediation Industry

This is the first in a series of Fact Sheets describing emerging markets that add value to the recycled organics industry. The target audience includes recycled organics processors, regulators, environmental consultants and remediation contractors.
There are significant opportunities for the use of recycled organics and composting techniques in the bioremediation industry. This Fact Sheet gives a general overview of the bioremediation process with a particular emphasis on the use of recycled organics products.

What is Bioremediation?

Bioremediation refers to the use of biological treatments to clean up hazardous materials in the environment. These biological treatments generally take advantage of the natural metabolic processes of plants (termed 'phytoremediation') or micro-organisms to stabilise or degrade environmental contaminants.

Micro-organisms involved in bioremediation processes include:

- **Bacteria** - these generally use organic compounds (e.g. hydrocarbons) as an energy source and in the process convert them to innocuous by-products and ultimately into CO_2 and H_2O.
- **Fungi** – these generally produce enzymes that can breakdown larger organic compounds (eg. lignin in woody material) into smaller by products that can be processed by bacteria.
- **Actinomycetes** – a type of bacteria characterised by the presence of fine filaments. They are typically found in soil and give it its 'earthy' smell.

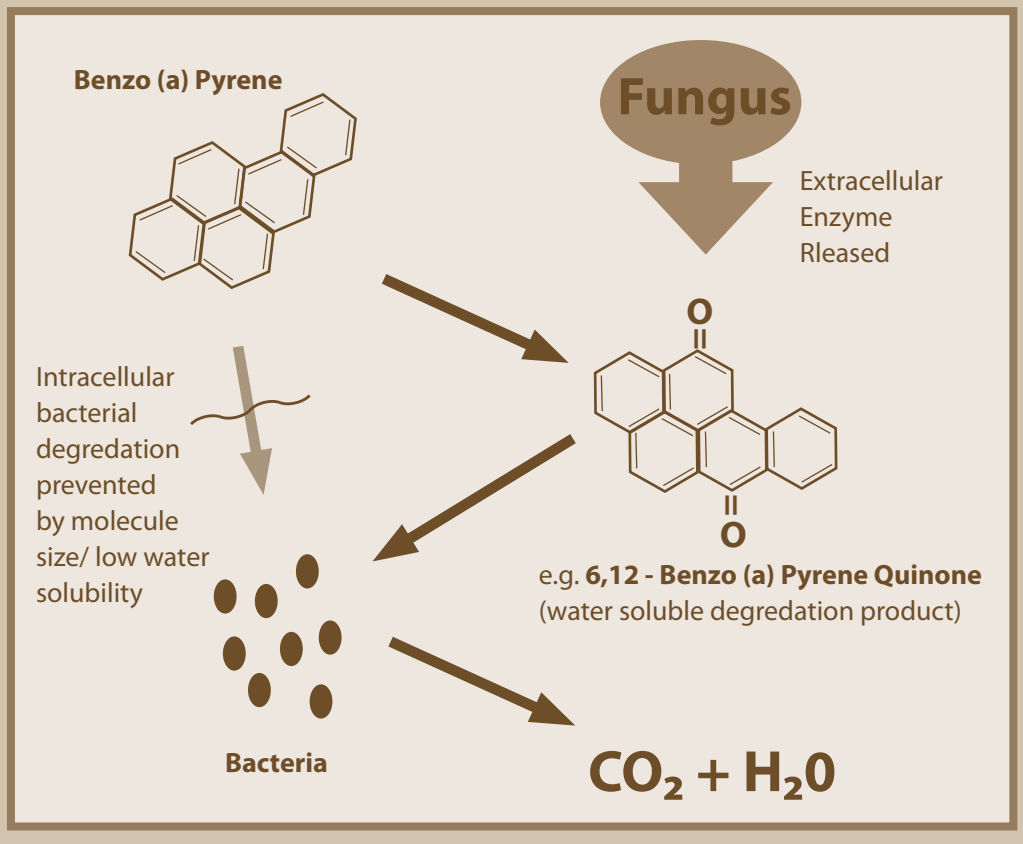

Figure 1: An example of how a diverse community of micro-organisms breaks down the organic contaminant benzo-(a)-pyrene.

Contaminated Soil

Benefits

Bioremediation offers the following advantages over other remediation methods:

- Generally cheaper than traditional physical and chemical remediation technologies;
- Environmentally friendly (converts most contaminants to water, carbon dioxide and innocuous by-products);
- Environmentally sustainable (treated soil can often be reused on-site avoiding landfill disposal);
- The process harnesses the highly specific and efficient metabolic processes of naturally occurring organisms.

Limitations

Bioremediation has the following limitations:

- Certain poly aromatic hydrocarbons (e.g. benzo-(a)-pyrene) and chlorinated compounds (e.g. Polychlorinated biphenyls) are recalcitrant to biodegradation. Inorganic contaminants such as heavy metals are not degraded by bioremediation (even though it can assist to 'lock them up');
- Bioremediation is a relatively slow process generally taking from several months to several years to complete;
- Sometimes contaminants are not 'bio-available' which mean that they are so strongly bound to the soil structure that they are not accessible to micro-organisms;
- Extreme environmental conditions (e.g. salt, pH, nutrients) or high concentrations of contaminants can be toxic to micro-organisms.

Target Contaminants

Bioremediation can effectively degrade or stabilise a wide range of contaminants. These are summarised in the table below:

Chemical Contaminant	Common Sources
PAH (Poly Aromatic Hydrocarbons)	Gas works, wood treatments (eg. creosote), industrial byproducts
PCP (Pentachlorophenol)	Biocides used in wood treatments, oils and paints
Total Phenols	Wood treatments, general industry
Heavy Metals (stabilisation)	Diverse industries, metal works, tanneries, refineries, smelters, mining
TPH (Total Petroleum Hydrocarbons)	Petroleum products, service stations, refineries, waste oil
BTEX (benzene, toluene, ethyl-benzene, xylene)	Petroleum products, service stations, refineries
TNT (Trinitrotoluene)	Explosives, mining and defence industries

Example of the ma

Bioremediation Technologies

There are a number of different bioremediation technologies used to clean up contaminated sites. These include:

- **Bioreactors (or bioslurry)** – treatment of a contaminated substance in a tank containing organisms or enzymes;
- **Bioventing** – involves the venting of oxygen through soil to stimulate the growth of natural and introduced bioremediation organisms;
- **Co-Composting** – generally involves mixing contaminated materials with either mature compost or fresh recycled organics. The mixtures are formed into turned windrows or engineered biopiles (see below);
- **Biopiles** – specially engineered static piles of mixed contaminated soil and remediation amendments usually involving a network of pumps and pipes for forced aeration;
- **Landfarming** – the use of farming tilling and soil amendment techniques to encourage the growth of bioremediation organisms in a contaminated area.

achinery used in the bioremediation process

Extracting contaminated soil

Using Recycled Organics for Bioremediation

Recycled organics are used extensively in bioremediation and in many cases underpin the basic requirements of the process. Often referred to as 'co-composting', the process is similar to commercial composting where windrows are constructed and technical parameters are monitored to ensure that optimal conditions for biodegradation are maintained. Recycled organics provide a number of benefits when utilised in the bioremediation process:

- A complex microbial community with a wide range of metabolic capabilities;
- Macro nutrients such as nitrogen, phosphorus and potassium;
- Trace elements essential for microbial growth;
- High porosity for the supply of oxygen and diffusion of air;
- Increased water holding capacity;
- Buffering capacity (particularly for high or low pH soils);
- Heat generation allowing increased bio-availability of some contaminants.

In bioremediation processes where forced aeration is used (e.g. biopiles, bioventing) a 'biofilter' is often employed to mitigate the emission of volatile compounds. Recycled organics (normally mature compost and coarse woodchips) are often a key component of the biofilter medium.

Recycled Organics Product Requirements

A purpose built windrow turner being used to efficiently mix recycled organics with silt trap material.

Recycled organics need to be tailored to the requirements of the bioremediation process. These requirements vary widely depending on the soil type, the extent and type of contaminants and commercial considerations. Recycled organics suppliers need to work closely with environmental consultants and remediation experts to determine the product quality requirements for specific bioremediation projects.

There are a number of general parameters that need to be considered when deciding on the quality requirements of recycled organics for bioremediation. These include:

Nitrogen content

For example, where high concentrations of organic contaminants (e.g. diesel) are being treated using a co-composting strategy, a high nitrogen source of organic amendments is often preferred to balance the required C:N ratio. In some cases, the organic amendments are supplemented with inorganic nitrogen or phosphorous based fertilisers.

Maturity

Some bioremediation processes require raw recycled organics feedstocks (e.g. green organics, woodchips) to simulate the composting cycle and to give physical structure and porosity to the bioremediation mixture. Other processes require more mature compost products to be added at a later stage of the process to stimulate microbial diversity or to generate a product fit for reuse.

Heating capacity

High temperatures can increase the mobilisation and bioavailability of certain organic contaminants (particularly hydrocarbons) during bioremediation.

Porosity

Just as for composting, the bioremediation matrix generally needs to be highly porous to enable adequate aeration.

Physical contaminants

Recycled organics and organic feedstocks often contain physical contaminants such as plastic or glass. These products generally do not adversely affect the bioremediation process. This creates a good market opportunity for recycled organics processors to use their lower grade products (i.e. physical contaminants) for bioremediation applications. Obviously where the treated material is being reused for landscaping purposes contaminants may pose a problem for reasons of safety or aesthetics.

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