SOILSINEW SOIL REMEDIATION

INTRODUCTION:

SoilsiNew® Soil Remediation is a highly concentrated biological amendment containing heavy metals remediating microorganisms, organic substances, and trace elements for soil remediation will reduce contamination from organic and petrochemical hydrocarbons (fuels, oils, solvents, greases, fractals, etc.)

By combining our unique bacterial blends together with our nutrients and considering your site specific parameters we will come up with a workable plan and timetable to mitigate the impacted site efficiently.

BENEFITS:

- Accelerates mineralization of soil organics for improved plant nutrient uptake
- Boosts plant photosynthesis
- Improves phosphorus uptake
- Improves crop yield and production
- Enhances soil health and microbial biodiversity
- In order to achieve a nearly 66% increase in Soil Organic Carbon (SOC) in less than 6 months would normally take 10 years

INCREASING SOIL ORGANIC CARBON:

- Nature has, by most scientific accounts, the most advanced technology on earth, with soil microbes the only present technology that can improve both carbon sequestration and CO_2 storage.
- Right now, industrial and conventional agriculture practices create between 44% and 57% of CO_2 emissions. Also, beneficial soil microbes in conventional soil have been reduced between 1000 and 5000 colony forming units (CFUs).
- When you compare this to organically farmed silt loam soil, where upwards of 1 million CFUs per gram of soil can be achieved after 12 to 15 years of heavy amending, the difference is clear, although the time-frame is obviously not optimal.
- Today however, we have an industry first: the capability to both regenerate and sustain large colonies of microbes using microbial fertilizer. In fact, the 12 to 15 year period can be now be completely circumvented, and 1 million CFUs can be achieved in less than 30 days.
- Another benefit is that carbon sequestration rates are higher when using microbial fertilizer, due to both the high population and diversity of the microbe strains it produces and its natural aerobic environment.

INCREASING SOIL ORGANIC CARBON: (cont.)

- Even more, plants grown in microbial fertilizer absorb more CO_2 and carbohydrates, and have a bigger root biomass, which allows their crop residue to deliver even more carbon.
- This extensive microbial life then assimilates a variety of sequestered carbon forms, storing them in the soil for later use. Mineralization then begins as the carbon and/or organic matter levels increase, transitioning these various carbon sources into fertilizers like nitrate nitrogen that plants can more easily uptake.
- Our soil scientists say that, in order to achieve a nearly 66% increase in Soil Organic Carbon (SOC) in less than 6 months would normally take 10 years.
- Right now there is no other way to increase soil microbes on this scale or magnitude

INTRODUCTION:

SOIL POLLUSTION

- Soil Pollution is defined as the build-up in soils of persistent toxic compounds, chemicals, salts, radioactive materials, or disease causing agents, which have adverse effects on plant growth and animal health. It is caused by the presence of xenobiotic (human-made) chemicals or other alteration in the natural soil environment.
- The most common chemicals involved are petroleum hydrocarbons, polynuclear aromatic hydrocarbons (such as naphthalene and benzo(a)pyrene) , solvents, pesticides, lead and other heavy metals.

WHAT ARE HEAVY METALS?

There are 2 categories of heavy metals:

- Essential heavy metals
  - ❖ Essential trace elements require very low quantities, but are important for the proper functions of various biological systems.
  - ❖ Iron, Zinc, Manganese, Copper, Cobalt, Selenium, etc. are known as the essential heavy metals.
- Non-essential heavy metals
  - ❖ Metals found in trace amounts in the human body are known as non-essential heavy metals – they are harmless if they stay below the “threshold level.”
  - ❖ Chromium. Silicon, nickel, etc. are known as the non-essential metals.
- Heavy metals have densities five times greater than water, and the light metals have lower densities.
- Humans consume metallic elements through water and food.

WHAT ARE HEAVY METALS? (cont.)

Heavy metals are metallic chemical elements having atomic weight between 63.54 and 200.59 , and a specific gravity greater than about 5.0 g/cc. They are toxic, can damage living things at low concentrations and tend to accumulate in the food chain. The most common heavy metal contaminants are : As, Cd, Cr, Cu, Hg, Pb, and Zn .

Chronic problems associated with long-term heavy metal exposures are:

•Lead – mental lapse.

•Cadmium – affects kidney, liver, and GI tract.

•Arsenic – skin poisoning, affects kidneys and central nervous system.

High levels of metals in soil can be phytotoxic. Poor plant growth and soil cover caused by metal toxicity can lead to metal mobilization in runoff water and subsequent deposition into nearby bodies of water. Furthermore, bare soil is more susceptible to wind erosion and spreading of contamination by airborne dust.

SOURCES OF HEAVY METALS

- Manufacturing, and the use of synthetic products like pesticides, paints, batteries.
- Municipal and industrial waste.
- Mining waste.
- Accidental Spills.
- Sediment from waste water treatment plant.
- Leachate from solid waste treatment plant.
- Acid rain.
- Nuclear wastes.

REGULATORY LIMITS FOR HEAVY METALS

SOIL CONCENTRATION RANGES AND REGULATORY GUIDELINES FOR SOME TOXIC METALS		
Metal	Soil Concentration Range[1] (mg kg^{-1})	Regulatory Limits[2] (mg kg^{-1})
Pb	1.00 – 6,900	600
Cd	0.10 – 3.45	100
Cr	0.05 – 3,950	100
Hg	<0.01 – 1,800	270
Zn	150.00 – 5,000	1,500

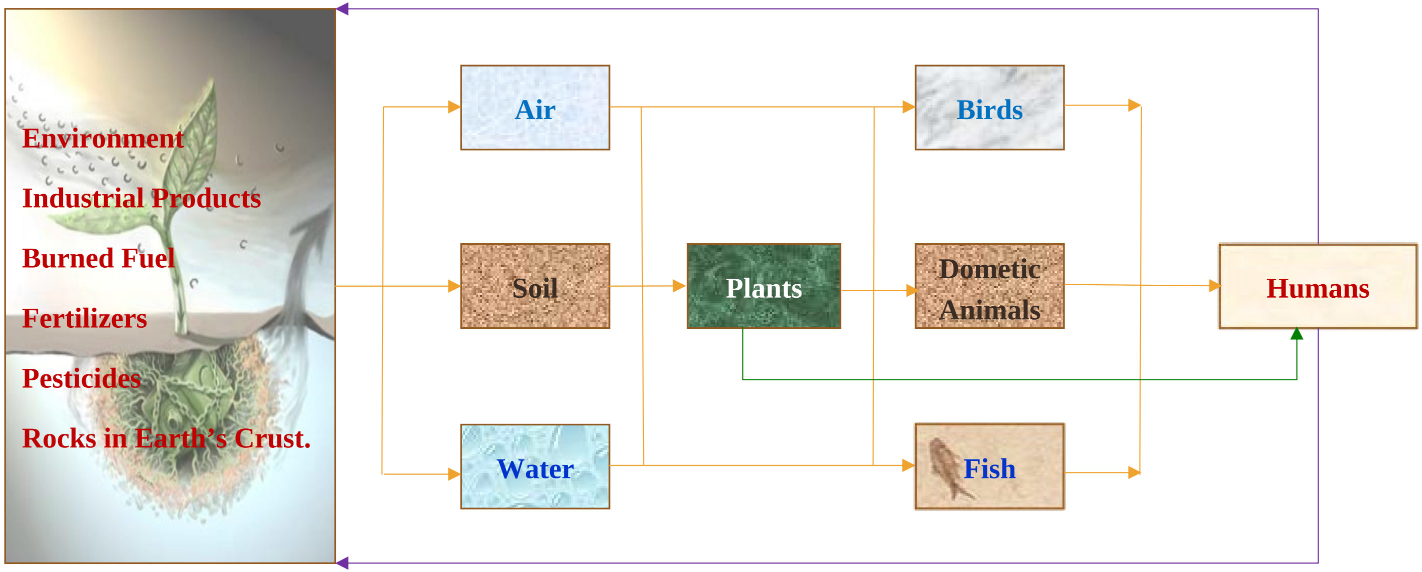
[1] *Riley et al., 1992*

[2] *Nonresidential direct contact soil cleanup criteria (NJDEP, 1996)*

SOME TRADITIONAL TREATMENTS FOR SOIL CONTAMINATION

- Traditional treatments for metal contamination in soils are expensive and cost prohibitive when large areas of soil are contaminated. The treatments should be done in situ (on – site), or ex situ (remove and treated off – site). Both are extremely expensive.
- There are some treatment are available include:
  - Vitrification (long – term monitoring)
  - Landfilling (translport/excavation/monitoring)
  - Chemical treatment (Recycling contaminants)
  - Electrokinectics (monitoring)
  - Phytoextraction (monitoring)
- Once metals are introduced and contaminated the environment, they will remain. Metals do not degrade like carbon – based (organic) molecules. The only exceptions are mercury and selenium, which can be transformed and volatilized by microorganisms.

SOURCE OF HEAVY METALS AND CYCLING IN THE SOIL-WATER-AIR ORGANISM ECOSYSTEM



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Anthropogenic Sources of Heavy Metal in Soil:

- Distillery
- Tannery
- Battery
- Mining
- Fly Ash
- Smelting
- Steel
- Electroplants

USING BIOREMEDIATION:

- It is preferred to use microorganisms to remove environmental pollutants or to prevent pollution. Use microbes to remove organic wastes leading to environmental release in the form of bioremediation.
- Apply the main biological processes to treat ground, water, soil, and sludge contaminated with hazardous chemicals. Precipitate effectively immobilizes inorganic pollutants such as heavy metals.
- Because biological processes are ultimately solar-driven, Phytoremediation is on average tenfold cheaper than engineering-based remediation methods such as soil excavation, soil washing or burning, or pump-and-treat systems. Phytoremediation is usually carried out in situ contributes to its cost-effectiveness and may reduce exposure of the polluted substrate to humans, wildlife, and the environment.

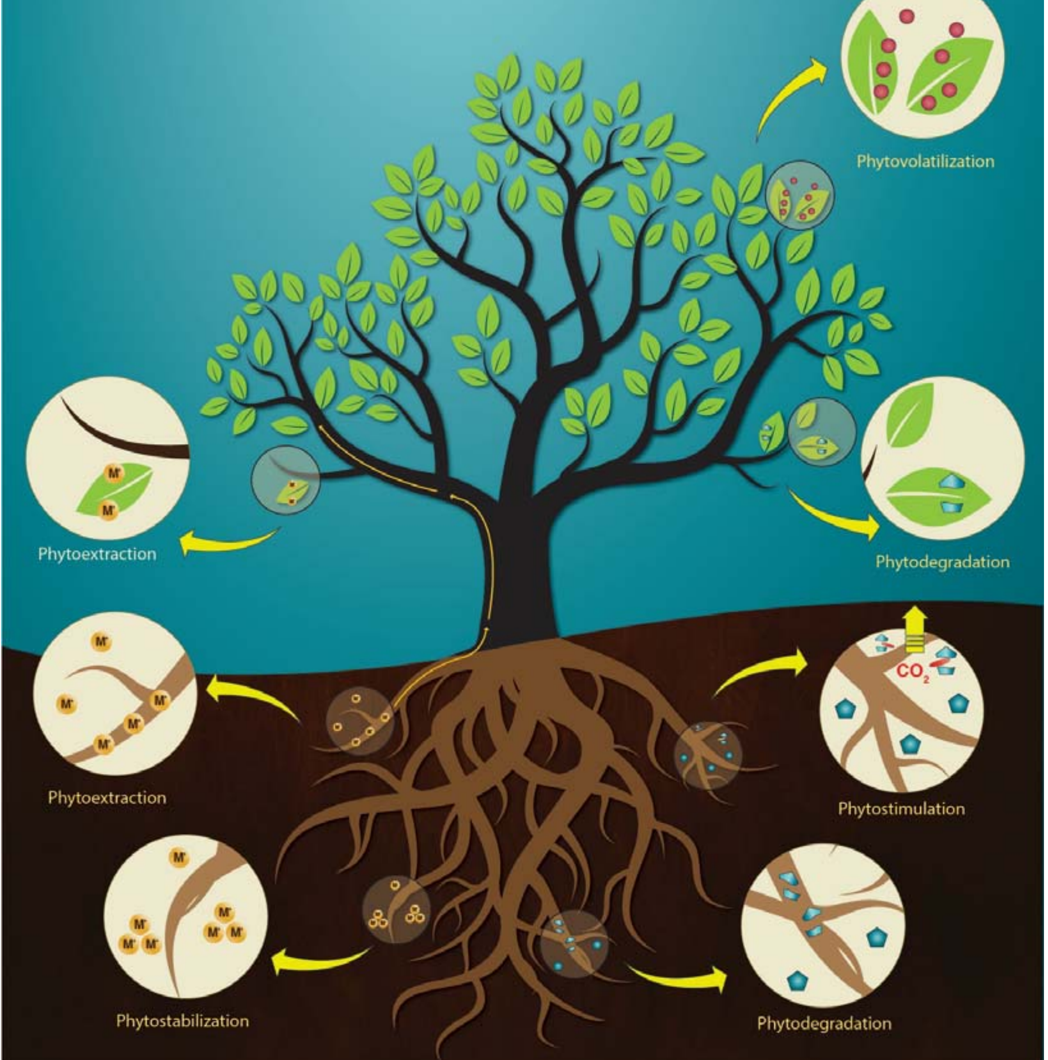
USING GRASSES AND MUSHROOMS AS POTENTIAL PHYTOREMEDIATION:

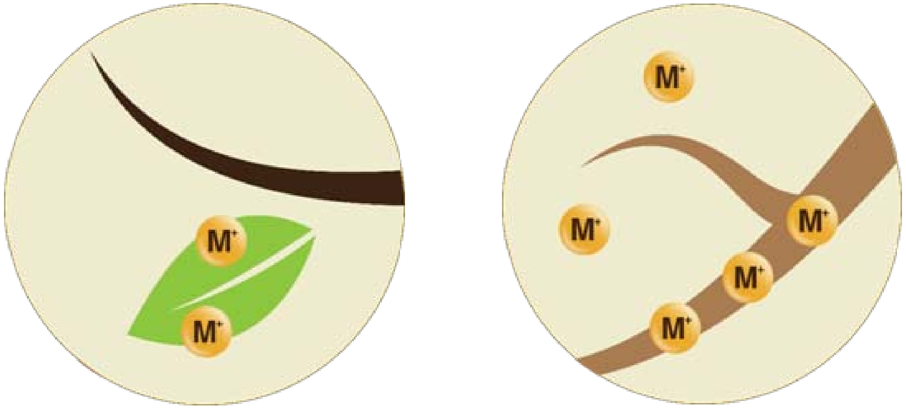
Phytoremediation is combined by “phyto” (plants) and “remediation” (clean or remove). Phytoremediation is the application of controlling and relocating various types of pollutants from the environment with plants including grasses and mushrooms. Depending on the underlying processes, applicability, and type of contaminant, phytoremediation can be broadly categorized as:

•To Treat Organic Contaminants : Phytodegradation, Phytostimulation, and Phytovolatilisation.

•To Treat Metal Contaminants : Phytoextraction , Rhizofiltration, and Phytostabilisation

PHYTOREMEDIATION



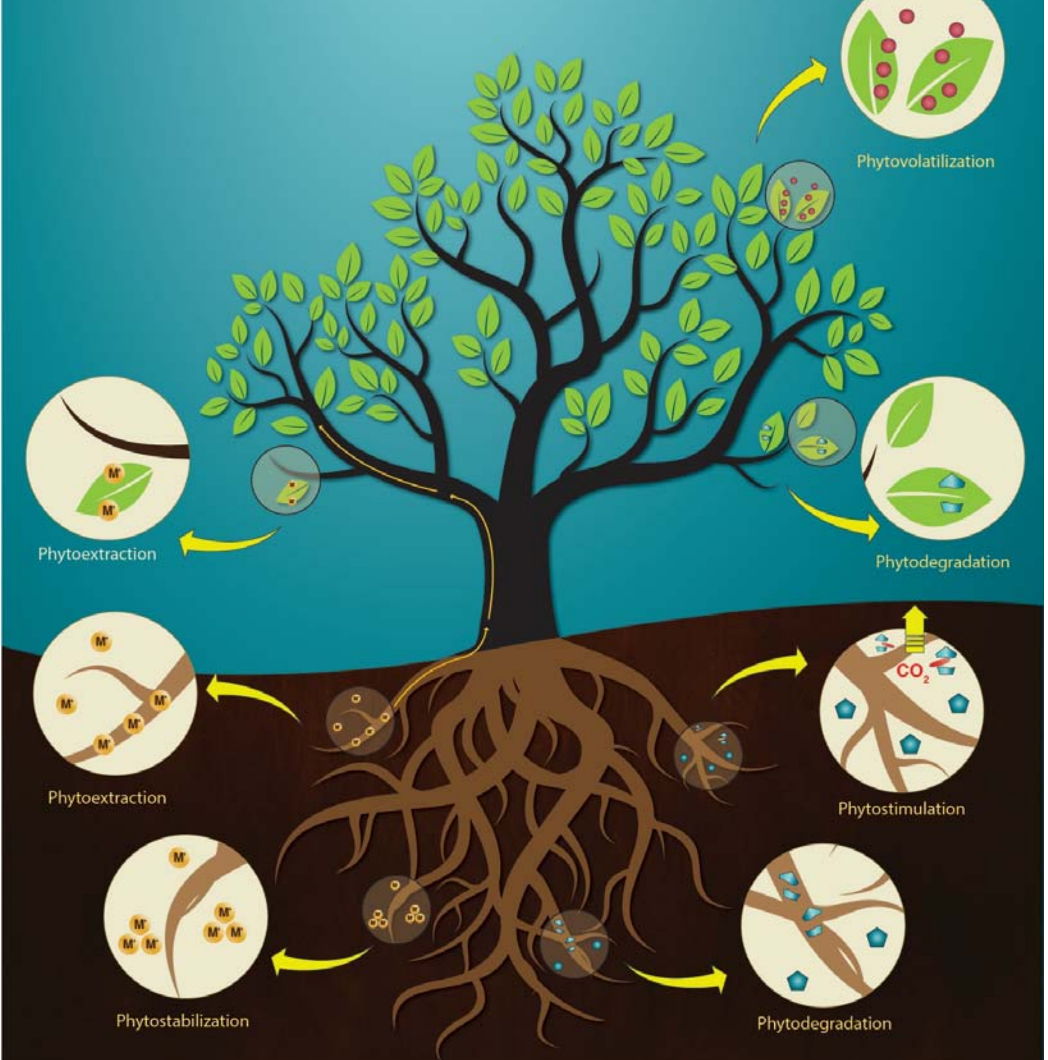


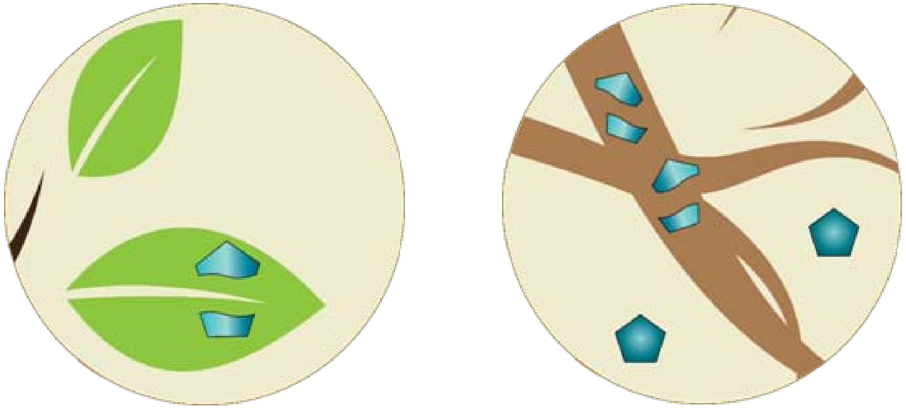
PHYTOEXTRACTION

The process is also known as Phytoaccumulation, Phytoabsorption, or Phytosequestration.

•Extracting the heavy metal (such as Cd, Ni, Cu, Zn, Pb, Se, As) and organic compound in soil including translocation method to uptake the contaminant by using plants' roots.
•The rate of Phytoextraction depends on how deep of roots in soil since plants' roots perform as the metal aggregation.
•This procedure specially utilizes hyperaccumulator plants, that can store high convergences of particular metals in their airborne parts (0.01% to 1% dry weight, contingent upon the metal).

PHYTOREMEDIATION



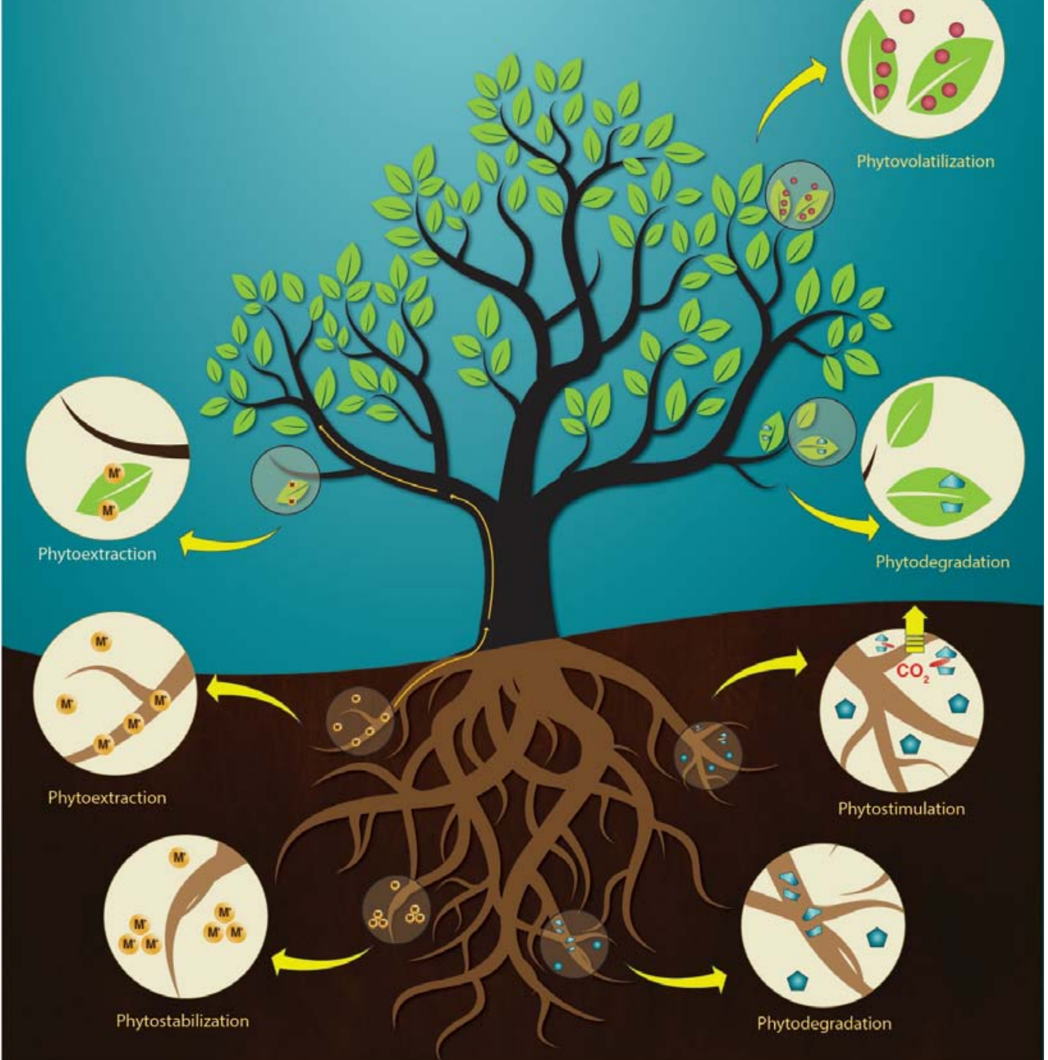


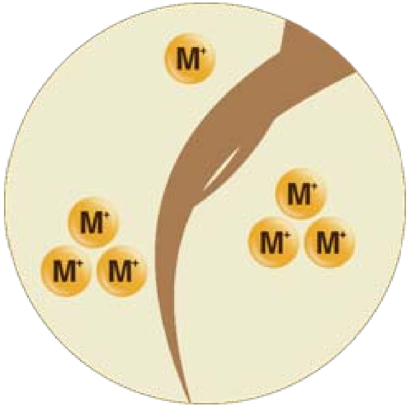
PHYTODEGRADATION

The process is also known as Phytotransfomation.

•Using the plant internal and external metabolism by breaking down the contaminant for uptake.
•Phytotransformation depends on the polarity, hydrophobicity, and solubility of the medium. It is different from rhizodegradation that uses microorganisms as the main medium. In soil, the organic contaminant are easily broken down by microbial activities.
•Natural contaminants are debased (processed) or mineralized inside plant cells by particular catalysts that incorporate nitroreductases (corruption of nitroaromatic mixes), dehalogenases (debasement of chlorinated solvents and pesticides) and laccases (debasement of anilines).

PHYTOREMEDIATION



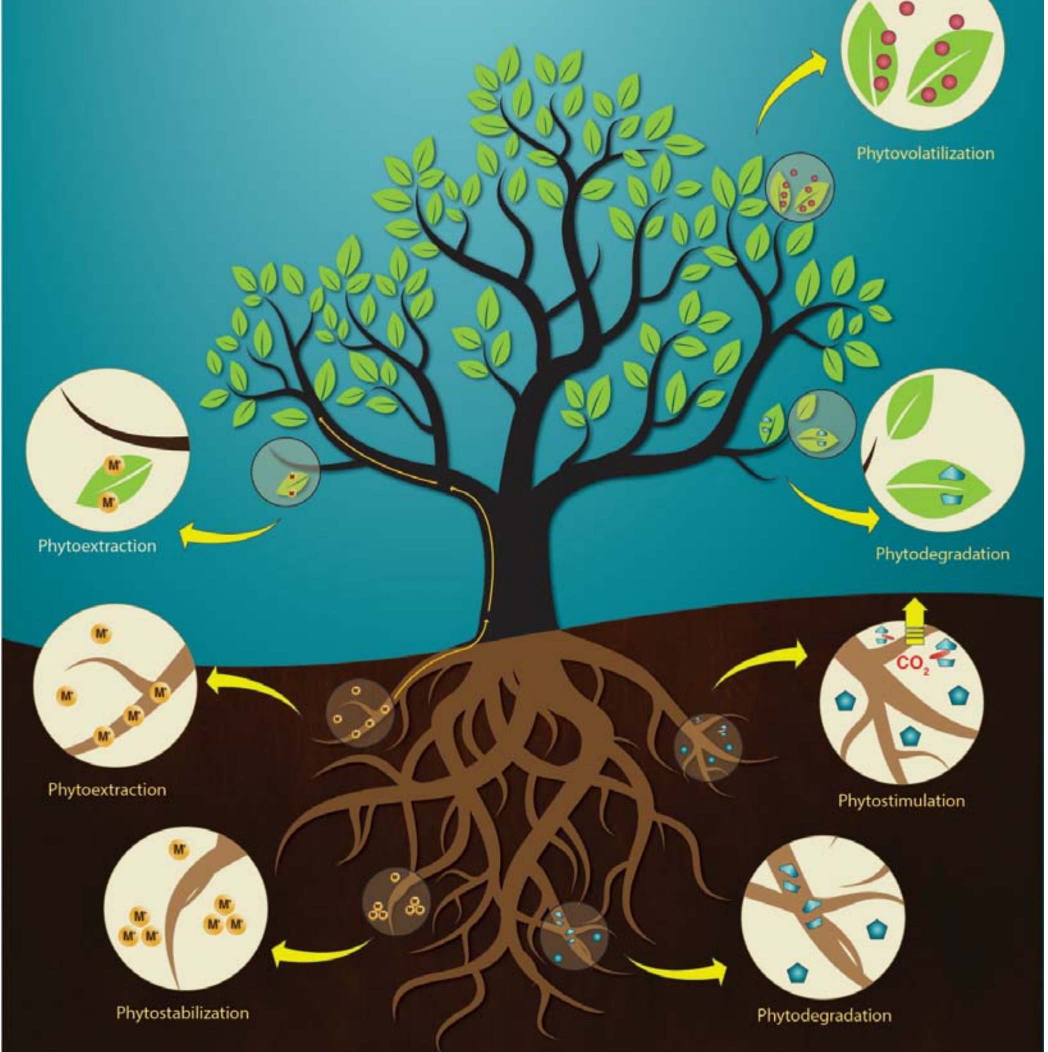


PHYTOSTABILIZATION

The process is also known as Phytoimmobilization.

- All of contaminants either organic or inorganic are consolidated into the lignin of the cell mass of roots cells or into humus.
- Metals are encouraged as insoluble structures by direct activity of root exudates and in this manner caught in the soil structure.
- The fundamental goal is to maintain a strategic distance from activation of contaminants and farthest point their dissemination in the dirt.

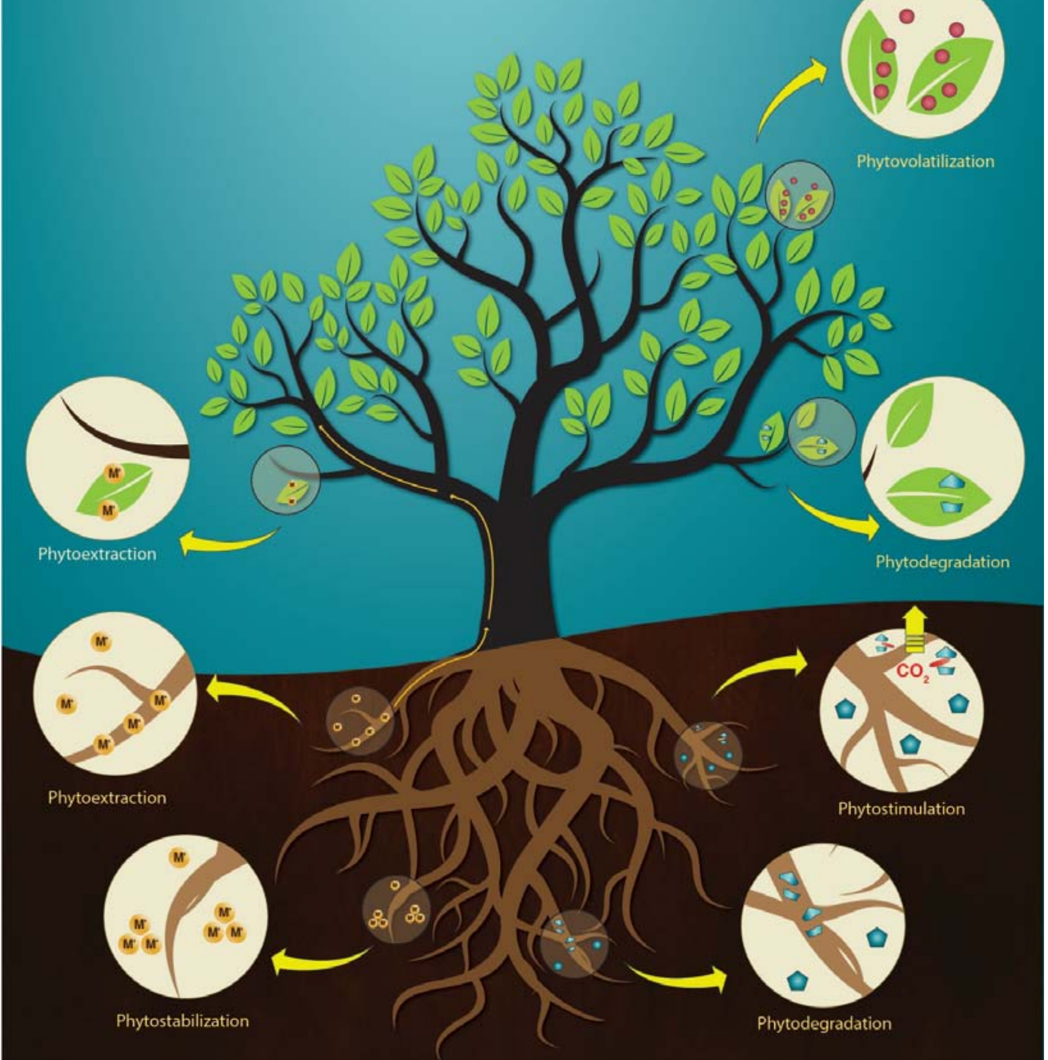
PHYTOREMEDIATION



PHYTOVOLATILIZATION

•This technique relies on the ability of some plants to absorb and volatilize certain metals/metalloids.
•Some element ions of the groups IIB, VA and VIA of the periodic table (specifically Hg, Se and As) are absorbed by the roots, converted into non-toxic forms, and then released into the atmosphere.

PHYTOREMEDIATION



PHYTOVOLATILIZATION

•This uses plants to absorb, concentrate and/or precipitate contaminants, particularly heavy metals or radioactive elements, from an aqueous medium through their root system or other submerged organs. The plants are kept in a hydroponic system, whereby the effluents pass and are “filtered” by the roots (Rhizofiltration), or other organs that absorb and concentrate contaminants. Plants with high root biomass, or high absorption surface, with more accumulation capacity (aquatic hyperaccumulators) and tolerance to contaminants achieve the best results.

•Known as the effective process by adsorbing contaminant carried surround root zone in biotic or abiotic method.

•Happening on the surface water, wastewater, groundwater as hydroponic method since the plant roots can contact with water.

FORAGE SEEDS WITH SOIL REMEDIATION:

- Forage Seeds is a biomass producer that grows 5 to 12 feet tall with long and slender leaves, it diameter of the stalks are up to one-half inch, and active root systems. It usually produce ample biomass between 4000 to 5000 lbs. DM/A. With multiple cutting on fertilized soils with adequate moisture, it can produce up to 18000 lbs. DM/A biomass.
- The main root exudate called sorgoleone, is a strongly active at extremely low concentrations compare with some synthetic herbicides. As early as five days of germination, it will begins to produce the allelochemical that persists for weeds. The plant also produce another natural compounds called nematicidal that suppress nematodes and other pest development.

NUTRITIONAL FEEDS

- **ENERGY SOURCES**:

  Light energy, in the chemical bonds of organic compounds (sugars or starches), in the bonds of inorganic compounds.

- **BASIC ELEMENTS NEEDED TO MAKE AND REPLACE CELL STRUCTURE OF ORGANISMS**:

  Macro-nutrients

  Secondary nutrients

  Micro-nutrients.

- **IDENTIFICATION OF MICROBES ON THE BASIS OF HOW NUTRITIONAL NEEDS**:

  Heterrotrophs depend on the organic compounds in the environment - carbon sources, sugars, starches, fats, and other organic matters.

  Autotrophs derive the energy from the non-organic sources with phototrophs and chemotrophs).

BENEFICIAL MICROORGANISMS

Make soil alive.
Break down organic matter.
Recycle nutrients.
Create humus.
Create soil structure.
Fix nitrogen.
Promote plant growth.
Control pests and diseases to help soil health.
Heal soil
Reduce overuse of fertilizers, erosion, and runoff as a consequence of unsustainable farming practices.
Save cost and Increase yield.

IDEAL COMBINATION: FORAGE SEEDS + SOIL REMEDIATION + NATURE VIGOR + CARBON LIQUID = CLEAN AND HEALTHY SOILS

FORAGE SEEDS	SOIL REMEDIATION	NATURE VIGOR	CARBON LIQUID
• Forage Seeds are a heat-loving plants that are excellent for emergency forage backup. • Forage Seeds works as potential phytoremediation. • Use solar energy and is low cost.	• Extracting heavy metals. • Using special microbes targeted to consume and break down hydrocarbons and other pollutant in soil. • Reduction of surface runoff. • Reduction of leaching and mobilization of contaminants in soil.	• Increases efficiency of fertilizers, chemicals and amendments. • Chelate soil nutrients. • Up to 30% yield increases • Improve nutrient uptake, especially phosphorus, sulfur, and nitrogen. • Solubilize minerals • Act as a storehouse of N, P, S, and Zn • Stimulate soil biological activity • Improve water-holding capacity for better drought resistance and reduction in water usage.	• Salt Remediation • Reduce Soil Compaction • Enhance Buffering Capabilities • Superior Nutrient Complexation • Increased Water & Nutrient Availability • Boost Healthy Microbial Activity

MICROBIAL/OIL ASSAY SYNOPSIS:

Oil Samples	Alkane BioRem	H_2S Elimination	Microbial Growth on Alkane	Globule Formation
1454	+++	+++	+++	+++
1049	+++	+++	+++	+++

Legend: + = Week Activity ++ = Moderate Activity +++ = Strong Activity

RESULTS:

***Alkane BioRemediation Assay*:**

Hydrocarbon reduction and remediation of the heavy oil samples by the petroleum microbials was demonstrated in the Alkane Remediation Assays. Petri plates were coated with microbial colonies and a heavy oil sample and allowed to incubate for 72 hours. Colonies formed all around and throughout the hydrocarbon substrate demonstrating digestion and metabolism of the alkane, as well as more complicated hydrocarbons that are present in the heavy oil. Both samples demonstrated good microbial colony plate growth on oil.

RESULTS:

<u>Hydrogen Sulfide Control Assay</u>:

An H_2S test comparison between the untreated heavy oil samples and the microbially treated ones. Visually, the black color is H_2S forming due to SRB (Sulfate Reducing Bacteria) present in the hydrocarbon substrate. Both tubes on the right are the microbially treated samples with the heavy oil and nitrate reducing bacteria. The SRB's have been eliminated via competitive inhibition and the presence of hydrocarbon bacteria has fundamentally shifted the microbial profile and thus the final end products away from H_2S. Both microbially treated samples (1454 & 1049) demonstrated effective control of SRB's and eliminated H_2S.

RESULTS:

***Microbial Growth on Alkane Assay*:**

The oil samples were split into two groups – untreated controls and treated samples. A microbial inoculation of 7 million CFU/ml was transferred into the treated samples. Spectrophotometer readings were taken over the course of 6 days to measure absorbance values. Absorbance values demonstrate wavelength disturbance through the test tube due to increasing microbial growth concentrations interfering with the light pathway originating from the spectrophotometer.

From Day 1 to Day 6 there was a significant increase in microbial mass in the treated oil samples versus the untreated samples, as well as a substantial color change in the microbially treated samples (dark color). This result proved that the bacteria were able to utilize and metabolize carbons from the hydrocarbon chains, thus resulting in smaller hydrocarbon chains and more easily moveable oil, as measured by globule formation.

→ Table of Treatment Below:

RESULTS:

Treatments**	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Untreated 1454	1%	2%	1%	1%	1%	1%
Microbial Treated 1454*	15%	35%	65%	85%	98%	100%
Untreated 1049	1%	2%	1%	1%	1%	1%
Microbial Treated 1049*	16%	33%	68%	82%	96%	100%

* Increasing Bacterial Absorbance readings equate to increasing micorbial growth on hydrocarbons as a carbons and food source.

** Maintained at 190^{o}F

GLOBULE INFORMATION:

- Small oil globule formation was demonstrated in both microbially treated samples (1454 & 1049).
- The key to improved oil production and recovery in heavy oil reservoirs is healthy bacterial action that results in an increased oil surface area.
- One must keep in mind that heavy oil reduction is not an instant process and thus, will take time depending on the environment and temperature.
- The oil globules are further reduced by microbial action through the alkane degradation pathway.

GLOBULE INFORMATION:

		
Left: Sample 1454 – Untreated (Top) vs. Microbially Treated (Bottom) Right: Sample 1049 – Untreated (Top) vs. Microbially Treated (Bottom)	Close up: Sample 1454 Top: Untreated Bottom: Microbially Treated	Close up: Sample 1049 Top: Untreated Bottom: Microbially Treated

APPLICATION:

Applications include in furrow, back pack spraying, soil drenching, side dressing and blending into the irrigation lines.

•Treat at 4 liters per hectare.

•Pre-plant/At planting – Apply at pre-plant or at planting. If possible, re-apply 4-6 weeks post germination.

•Post Application: Apply a soil acidifier to the contamnated soild to allow chelation and removal of the metals and soil contaminants.

•Can blend with liquid and dry fertilizers and soil amendments.

•Agitate well before use and store in a cool, dry location.

•Keep cap closed when not in use.