



An issue particular to hydrocarbon impacted soil - Hydrophobicity



- Hydrophobicity (or water repellency) is caused by the coating of soil particles with hydrocarbons. When crude oils contact soil the likelihood of the soil becoming hydrophobic depends on:
 - ✓ The properties of the crude oil (greater proportions of heavies and waxy hydrocarbons)
 - ✓ The dryness of the soil at the time of first contact with oil
 - ✓ Prolonged exposure to hot dry weather and ultraviolet light
 - ✓ Time
 - ✓ All of these factors increase the likelihood producing a hydrophobic soil
- Even bioremediated soil can be hydrophobic
- Hydrophobicity can inhibit revegetation, the soil repels water reducing water availability to plant roots
- Hydrophobicity is counteracted by hydrophilic (water loving) organic matter (hay or composted manure, for example) and hydrogels
 - ✓ Use **BioN^hance+** during the remediation of crude oil impacted soils
 - ✓ Use **RestorN^hance™** during revegetation of hydrophobic soils
 - Both contain stable organic matter and hydrogels which:
 - Increase the water holding capacity of the soil
 - Increase contact of water with hydrophobic soil particles making them more likely to wet

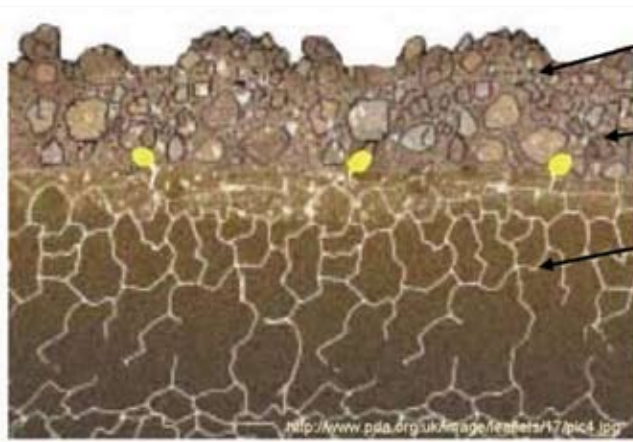


Revegetation of former hydrocarbon- and brine-impacted sites

- Natural revegetation? Requires
 - ✓ Adequate moisture
 - ✓ Desired vegetation immediately adjacent to site
 - ✓ If and when the desired vegetation makes up > 20% of the plant canopy cover then natural revegetation with the desired plant community is possible; weed management strategies may be required to give the desired plants a foothold in the site:
 - Hand pulling of weeds
 - Spot treatment with herbicides
 - Transplanting of desired vegetation
 - Monitor and attend to weeds frequently; if weeds become established then revegetation with desired plants can become very expensive
- Reseeding a remediated site, replacement soil, or other restoration site
 - ✓ Assess the overall quality of the soil
 - Salinity: ideal < 2 mS/cm, acceptable is whatever can be tolerated by the desired vegetation
 - SAR: ideal < 6, acceptable < 10
 - Bulk density (g dry soil/cm³): ideal 1.4, acceptable 1.2-1.6
 - Reducing bulk density
 - Ripping and secondary tillage
 - Incorporation of organic matter (compost and biodegradable organic matter)
 - Limit access to livestock
 - Keep vehicles off the site
 - Soil texture: ideal loam, acceptable clay loam to sandy loam
 - Organic matter: ideal > 3%, acceptable > 2%
 - pH: ideal 6.4-7.5, acceptable 5.5-8.5
 - Primary and secondary plant nutrients:
 - Use an agricultural lab to provide recommendations for specific plant community desired
- Seedbed preparation
 - ✓ Plowing is the most common way of preparing a seedbed
 - Moldboard
 - Offset disk
 - ✓ Secondary tillage may be necessary to eliminate large clods
 - Large clods may result in seeds being buried too deep



Revegetation & Restoration of Soil



Organic matter to retain moisture

Soil loose enough to allow emergence; shallow enough to allow the seedling to emerge before running out of energy

Soil sufficiently firm to provide a stable foundation for roots but porous enough to allow for good root penetration



- ✓ At this stage incorporate any necessary soil amendments
 - Topsoil if needed
 - Compost for organic matter
 - In arid and semiarid areas use compost supplemented with hydrogels – captures and holds water
Recommended by USDA Dept. of Agricultural Research

- **RestorNhance[™]** *Revegetation and Restoration*
 - Incorporate into top 3 inches

- Fertilizer
 - As recommended by agricultural extension lab but never more than
 - 60 lbs/acre nitrogen
 - 60 lbs/acre P₂O₅
 - 60 lbs/acre K₂O

- ✓ Light packing of the soil provides a firm but penetrable seedbed
- ✓ Roughing the surface before seeding creates safe sites for seeds and collects moisture
- ✓ Light churning after broadcasting seeding facilitates good contact of the seed with soil
- ✓ Overlay with a layer of soil/compost/hydrogel product like

- **RestorNhance[™]** *Revegetation and Restoration*

- ✓ In areas that are very hot and windy plant a stubble crop the year before seeding with the desired vegetation (use a sterile annual cool season grass)
 - The next season rough the surface by light raking, sow seeds and pack lightly
 - Stubble crop provides shade and wind protection for new seedlings
- ✓ If on a slope protect the site from excessive runoff with soil berms or silt fences

➤ What to seed?

- ✓ Depends on management objectives
 - Forage crops
 - Native vegetation
 - Quick growing species for erosion control
 - Halophytes
 - Get advice from local soil conservation district office about species native to your area
- ✓ Choose plants that are adapted to soil, climate, elevation, and topography of the area to be restored
 - Consult local soil conservation service
 - See <http://plants.usda.gov>
- ✓ Important to know origin of seeds
 - Seeds should originate from sources from within 200 miles N and S and 100 miles E and W
- ✓ Use certified named varieties
- ✓ Mixtures are preferred over single species
 - Especially different rooting depths
 - Most efficient use of moisture and nutrients
- ✓ Use seed of known quality
 - Know germination and purity of seed
- ✓ Seeding rates are based on pure live seeds (PLS)
 - PLS = % purity X % germination



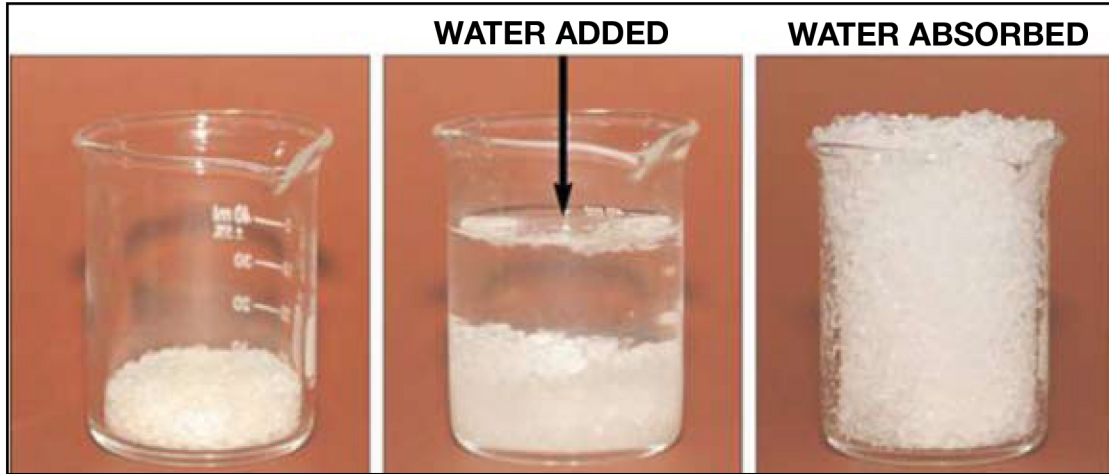


- When to seed?
 - ✓ Try to seed just before season of expected high rainfall
 - ✓ Cool season grasses may be planted in spring or early fall (ideally in the fall)
 - ✓ Warm season grasses in spring
- How to seed?
 - ✓ Broadcast seeding must be done on loose roughened soil, seeding is followed by churning or cultipacking
 - ✓ Recommended seeding rates based on PLS/acre
 - Seeding rates are typically 20-50 seeds/ft²
 - ✓ Depth
 - Seeds have stored energy, sprout must break the surface and produce leaves before getting energy from the sun. If the seed is planted too deep the sprout can't make it to the surface
 - General rule of thumb – plant seeds at a depth 4-7 X the diameter of the seed
 - With a mixture base planting depth on the diameter of the smallest seed
 - Avg ¼ - ½ inch
- Common causes of planting and emergence problems
 - ✓ Insufficient moisture
 - ✓ Seedbed too hard or too loose
 - ✓ Many of the seeds were dead before planting or had low vigor.
 - ✓ Too few seeds were planted. If broadcasting, many more seeds are required to allow for irregular distribution.
 - ✓ Seeds were planted too deep.
 - ✓ Seeds were planted into a seedbed that had dried out leading to uneven germination.
 - ✓ Seeds were not uniformly distributed
 - ✓ Seeds were planted too shallow and dug up by birds or moved by insects.
 - ✓ Sowing occurred too long after cultivation allowing weeds to establish and compete with crop seedlings for resources.
 - ✓ Heavy rain fell after sowing and the soil surface crusted.
 - ✓ Insufficient organic matter resulting in sheet erosion and loss of seed
- Management of revegetation sites
 - ✓ If natural precipitation is inadequate – must water to establish seedlings!
 - Water only until plants are established, if well matched to the local climate they will persist with normal rainfall
 - Watch for drought stress during this period of establishment, monitor soil moisture
 - ✓ Light mulch protects seeds from wind and water erosion, conserves moisture, moderates soil temperature
 - Use local hay, weed free
 - Tackifiers (guar gum, polyacrylamides) or jute netting help in windy climates
 - ✓ Protect from grazing until roots have firmly established (usually 2-3 years)
 - ✓ Hand pull weeds or spot herbicide
 - ✓ Most grass seedlings can tolerate herbicide application after reaching the 4 leaf stage
 - ✓ Watch for foraging by wildlife, erosion, areas of revegetation failure
 - ✓ Monitor for signs of nutrient deficiencies
 - ✓ Nutrient management is especially important when gypsum has been use in remediation of brine spills!
- Shrubs as nurse plants (over story plants) are especially important in arid climates
 - ✓ Increases water available by moisture interception
 - ✓ Enhance soil fertility
 - ✓ Reduce evaporation
 - ✓ Improves soil structure
 - ✓ Increases nutrient cycling
 - ✓ Adds organic matter from litter

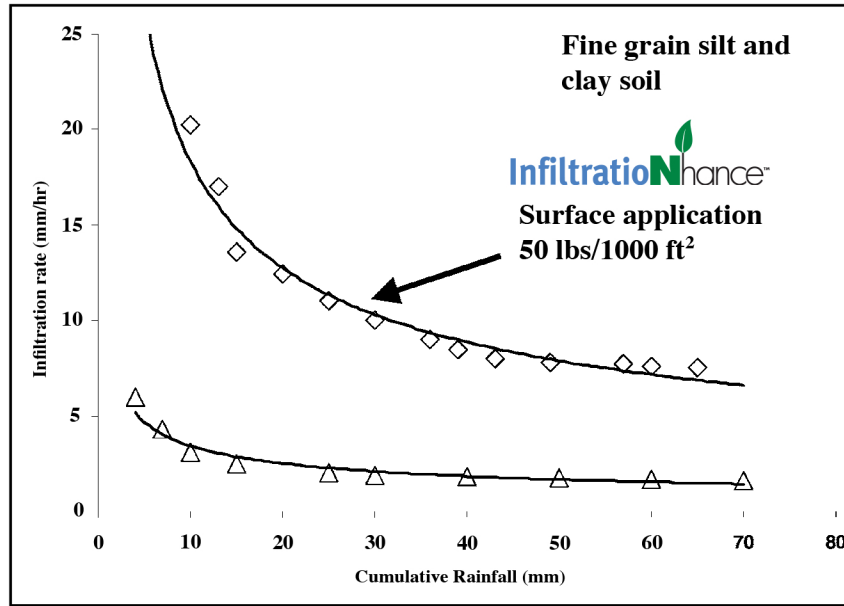


Release the Power of Hydrogels for Revegetation in Arid and Semi-arid Climates

RestorN^{hance} captures water and aerates the soil



Surface application of **InfiltrationN^{hance}** inhibits swelling of clays and maintains good rates of water infiltration into the soil



Need help? Contact Kerry Sublette of Sublette Consulting, Inc. at (918)691-0639 or ksublette@microbe.com.

For more detailed guidance on soil remediation and information on **Ca⁺⁺Nhance™** and **InfiltrationNance™**, as well as other products to support remediation of hydrocarbon-impacted soils and revegetation, go to www.bovairdsupply.com.

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