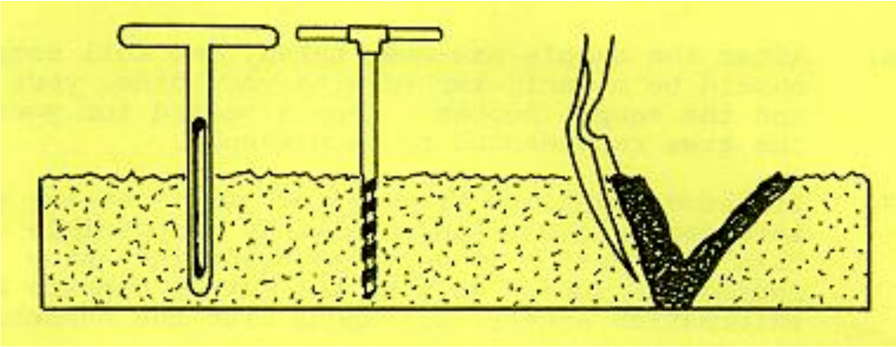
Appendix I

- Guidance for composite soil sampling
- The OSU sweatless soil sampler
- Special consideration for soil sampling and analysis when litigation is possible
- Sample direct count calculation
- Sample fertilizer calculations for landfarming crude oil
- Composting of petroleum hydrocarbons

Reference

Guidance on composite soil sampling

- Remove any surface debris from the area to be sampled.
- Dig holes about 6-8 inches deep (landfarming assumed)
- Scrape soil from the sides of the hole and mix in the hole breaking up clumps
- Take equal amounts of soil from each hole and mix well – this is your composite sample
- Avoid edges and unusual areas
- Best time to sample is when the soil is relatively dry and it is easy to break up clumps and mix the soil
- Don't resample from the same hole
- Each area of a site with distinguishing characteristics should be sampled separately



Reference

SWEATLESS SOIL SAMPLER

It is sometimes difficult to sample with regular soil probe when the ground is hard, but you can make an easy one for yourself. Here is why and how:

Reference

Advantages

- Easy to get into the soil
- Easy to control depth
- Samples are collected in the bucket for you
- Easy to Make
- Use what you already have
- Easily Modified

Reference

Parts Needed

- Long Ship Auger ¾" dia, 17-18" length
- 12-16" Extension
- Plastic bucket
- 1 ½" ¾" PVC schedule 40 pipe
- ¾" Threaded PVC coupler
- Conduit nut
- Cordless drill (12 to 18 volts recommended)

Reference

Soil sampling - Special considerations when litigation is possible

- Sampling personnel should have documented field experience and training in sampling
- All sample collection activities should be traceable through field records
  - Who did the sampling?
  - Where?
  - How?
  - What equipment used?
  - How was the sample preserved in the field, in the office, an up to the time it was shipped or carried to the lab?
  - How was the sample shipped and to where?

Soil sampling - Special considerations when litigation is possible

- Document sampling precision using duplicate samples
  - Collected at the same time by the same personnel in the same way etc.
- Document sample handling effectiveness
  - Field blank
    - Take a sample of a pristine soil to the field site (as similar as possible in texture to the soil to be sampled). Expose this sample to ambient conditions during the sampling process, then reseal it. Use the same sample containers and field preservation methods as used for the other samples. Ship this field blank to the laboratory along with the other samples in the same shipping container for the same analyses. This will show whether there was any possibility of contamination from exposure to hydrocarbon vapors in the field.

Soil sampling - Special considerations when litigation is possible

- Trip blank
  - Ship a sample of a pristine soil to the laboratory in the same shipping container as the field samples. Use the same type of sample container and shipping preservation method as used for the other samples. Have the same analyses performed on this pristine sample that will be performed on the field samples. This will show whether there was any possibility of cross contamination in transit.

- Clean your tools between grab samples
  - Phosphate-free laboratory detergent like Alquinox or Liquinox
  - Rinse with distilled water

Soil sampling - Special considerations when litigation is possible

- Sample chain-of-custody
  - Purpose is to document who has possession of samples from cradle to grave
  - Information required on chain-of-custody
    - Sample identification
      - Typically each sample must have a unique ID number as well as a description of the sample
    - Project number or other description of where the sample came from
    - Date and time of sample collection
    - Kind of sample – grab or composite
    - Medium (soil, sediment, surface water, etc.)
    - Whether the sample is preserved and how
    - Types of analyses to be conducted by the lab

Reference

Soil sampling - Special considerations when litigation is possible

- Sample chain-of-custody, cont.
  - Each person in possession of the sample(s) signs and dates the chain-of-custody when they take possession and when they relinquish possession
  - Definition of possession:
    - In your actual possession
    - Within your view after taking physical possession
    - Locked and sealed in a tamper-proof secure area after you took physical possession

Reference

Soil sampling - Special considerations when litigation is possible

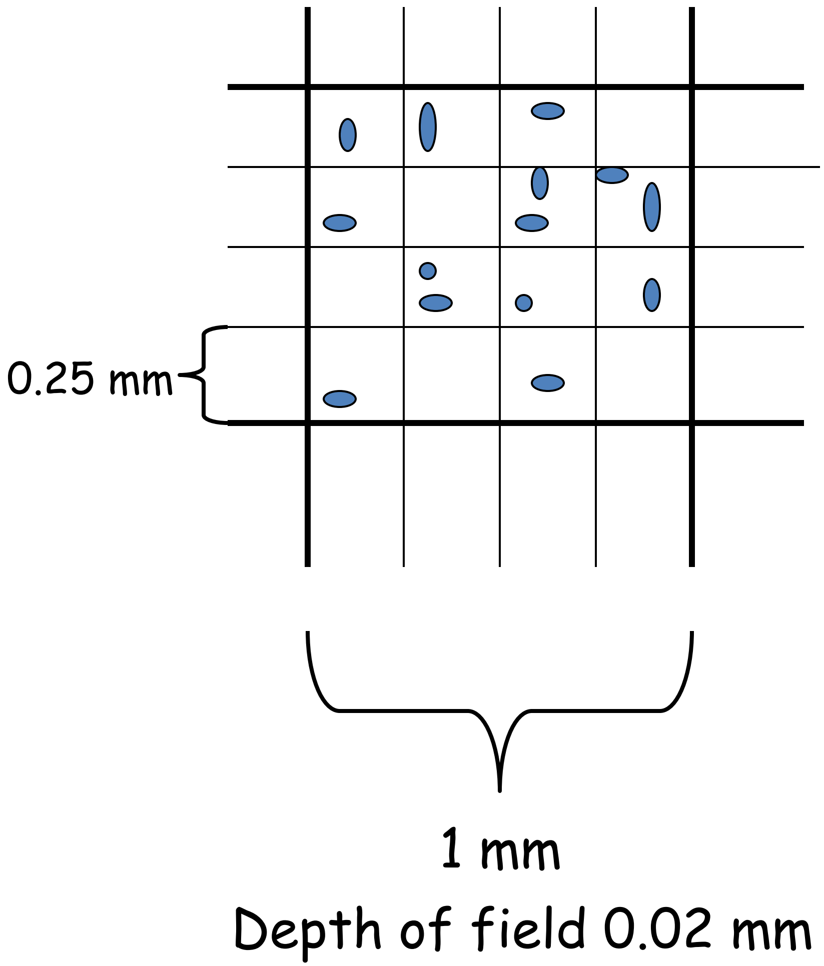
- Laboratory must have a quality assurance program which must include:
  - Document control procedures
    - Pre-printed data sheets and log books
    - An error correction procedure
    - Consistency of documentation
    - Document numbering and inventory procedures
    - Maintain shipping data and case files

Reference

Soil sampling - Special considerations when litigation is possible

- Written standard operating procedures (SOPs)
  - Receipt of samples
  - Maintenance of custody
  - Sample storage
  - Tracking analysis of samples
  - Assembly of completed data
  - Laboratory safety
  - Cleaning of glassware
  - Traceability of standards
  - Handling of confidential information

Sample direct count calculation



10 g of soil with 15% moisture is extracted with 95 mL of extractant

14 cells in 1 mm^2

Vol = 1 mm^2 x 0.02 mm = 0.02 mm^3

= 2×10^{-5} cm^3 (or mL)

14 cells/(2×10^{-5} mL) =

7×10^5 cells/mL extract

Sample direct count calculation, cont.

Total cells extracted = 7×10^5 cells/mL (95 mL)

= 6.7×10^7 cells

Concentration of cells in soil = $\dfrac{6.7 \times 10^7 \text{ cells}}{10 \text{ g } (0.85)}$

= 7.9×10^6 cells/g

(dry weight basis)

The following is a sample calculation or practice problem illustrating calculation of fertilizer requirements for landfarming of crude oil using C:N:P:K weight ratios and accounting for fertilizer salinity

Reference

Practice Problem

The rupture of a crude oil pipeline in 1992 in an isolated rural area resulted in the release of crude oil over an area of about 40 ft by 130 ft. At the time of the spill a vacuum truck was used to recover pooled oil but much contamination remained that could not be recovered. The impacted site was simply covered with hay and left alone. Recently the landowner has demanded that the spill be remediated. Preliminary site assessment has shown that the crude oil has migrated downward to a depth of three feet with TPH concentrations of 63,000 mg/kg dry wt of soil on average. The downward migration of the oil was stopped by a clay layer at 3 ft.

Reference

Practice Problem, cont.

Nearby the spill is an old tank battery. All of the tanks have long since been removed but the original containment berm is still in place. The total area within the berm is about 60,000 ft^2. Depth to groundwater is in excess of 60 ft. The decision is made to excavate the contaminated soil and replace it with soil from the berm (which is not contaminated with oil or brine). The excavated soil is to be land treated within the confines of the old tank battery.

Reference

Practice Problem, cont.

The API gravity of the residual crude oil is estimated to be 25 and the mean annual soil temperature (during the growing season) at the site is estimated to be 20 ^{o}C. Calculate initial nutrient amendments. Assume an average soil moisture content of 14 wt% and an average bulk soil density of 103 lb/ft^3.

bulk soil density is the dry weight of soil/the original volume of soil

Reference

Solution

Volume of contaminated soil

Volume of contaminated soil =

3 ft X 40 ft X 130 ft = 15,600 ft^3

or 1.56×10^4 ft^3

Dry weight of contaminated soil

15,600 ft^3 X 103 lb/ft^3 = 1,606,800 lbs or 1.61×10^6 lbs

Reference

Solution

We need to convert this to kg.

Why in kg? You need the dry weight of contaminated soil in kg so you can calculate the TPH inventory. The TPH concentration you receive from the analytical lab will likely be expressed as mg TPH per kg of soil on a dry weight basis (mg TPH per kg dry weight of contaminated soil).

Example: TPH = 63,000 mg/kg (dry wt. basis)

1,606,800 lbs X (1 kg/2.2 lbs) = 730,000 kg or 7.3×10^5 kg

Reference

Solution

TPH inventory

TPH inventory = Dry weight of contaminated soil in kg X TPH concentration =

7.3×10^5 kg X 63,000 mg/kg TPH = 4.6×10^{10} mg

Let's change that to kg

4.6×10^{10} mg TPH X 1 kg/10^6 mg = 46,000 kg or 4.6×10^4 kg

Now let's go back to lbs

46,000 X (2.2 lbs/kg) = 101,200 lbs

Solution, cont.

Surface area required for the landfarm

Loading rate should be about 4% TPH; therefore, dilution of contaminated soil with soil from berm required.

The soil is to be diluted from 6.3% to 4% so we say that 4/6.3 is the dilution factor

Final volume of contaminated soil = volume before dilution / dilution factor or

$$15{,}600 \text{ ft}^3 / (4/6.3) = 24{,}606 \text{ ft}^3$$

If soil is to be spread to a depth of 6 inches then the surface area required for land treatment is volume / depth or

$$24{,}606 \text{ ft}^3 / 0.50 \text{ ft} = 49{,}212 \text{ ft}^2$$

(Since there is 60,000 ft^2 we can spread the soil out over the entire area to minimize depth and get better oxygen transfer)

Reference

Solution, cont.

N,P,K requirements

Wt. C in TPH = 101,200 lbs X 0.80 = 80,900 lbs

N required (assuming initial C:N of 150:1) =

80,900 lbs/150 = 539.7 lbs

539 lb/60 = 9 lb N/1000 ft^2; very high, need to reduce to 3 lb N/1000 ft^2 if we're using something like NH_4NO_3 (SI =104) or 4 lb/1000 ft^2 if we can use urea (SI = 74).

3 lbs X 60 = 180 lbs for 60,000 ft^2

Reference

Solution, cont.

P required (assuming N:P of 5:1) =
180 lbs/5 = 36 lbs

P_2O_5 required = 36 lbs x 2.3 = 82.8 lbs

K required (assuming N:K of 5:1) =
180 lbs/5 = 36 lbs

K_2O required = 36 lbs x 1.2 = 43.2 lbs

Reference

Solution, cont.

Fertilizer Requirements

NH_4NO_3 (33%N)

180 lbs/0.33 = 545.4 lb

Triple superphosphate (0-45-0)

82.8 lbs/ 0.45 = 184.4 lb

Potash (0-0-51)

43.2 lbs/0.51 = 84.7 lb

Solution, cont.

What if the fertilizer you have is a blend, say 13:13:13?

Remember N is needed in the greatest quantities so calculate fertilizer requirements based on nitrogen.

180 lbs N/0.13 = 1384.6 lbs of 13-13-13

Would this give us enough P and K?

P_2O_5 required = 82.8 lbs

K_2O required = 43.2 lbs

1384.6 lbs X 0.13 = 180 lbs of P_2O_5 and K_2O

Composting of petroleum hydrocarbons

Petroleum contaminated soils

Tank bottoms

Drilling wastes

Composting

A modification of land farming:

- Contaminated soil is mixed with nutrients and bulking agents to improve aeration and drainage and arranged in windrows perpendicular to the prevailing wind direction
- Takes advantage of microbial heating
- Periodic mixing needed to improve aeration and control temperature
- May use a pad and leachate collection system. Best suited for highly contaminated soil, sludges, and slop oils but also used to treat drill cuttings

Steps in composting of hydrocarbon-contaminated soil

- Pre-treatment soil processing
- Amendments
  - Bulking agents
  - Nutrients
  - Moisture
  - Supplemental organic matter
- Blending and forming windrows
- Maintenance
  - Mixing
    - Frequent to maintain oxygen levels and control temperature
  - Nutrients
  - Moisture

Steps in composting of hydrocarbon-contaminated soil

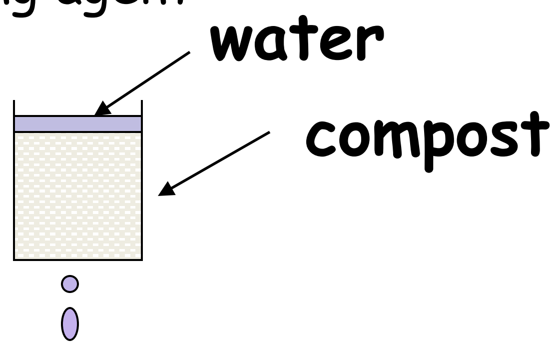
- Monitoring
  - Temperature (keep under 140-165 ^{o}F)
  - TPH (Field kits)
  - Moisture (capacitance probe)
  - Oxygen (soil gas analysis)

Bulking agents

- Wood chips
- Sawdust
- Tree bark
  - Wood chips, bark, and sawdust provide structure and aeration but little moisture retention
- Ground corn cobs
- Hay or straw
- Rice hulls
  - Agricultural by-products provide good moisture retention but structure building effects are lost as material decays

Bulking agents – How much?

- Volumetric ratios of 10-50% reported
- Coffee can test
  - Poke a hole in the bottom of a 2-lb coffee can and fill the can with compost
  - Try to pour water through the compost. If water does not flow through almost immediately you don't have enough bulking agent



Nutrients

- The same methods for predicting total nutrient requirements used with landfarming can be applied for composting
- Likewise all precautions about nutrient additions also apply (add nutrients in increments to avoid excess salinity)
- Periodic nutrient addition can be coupled with moisture addition

Composting petroleum wastes

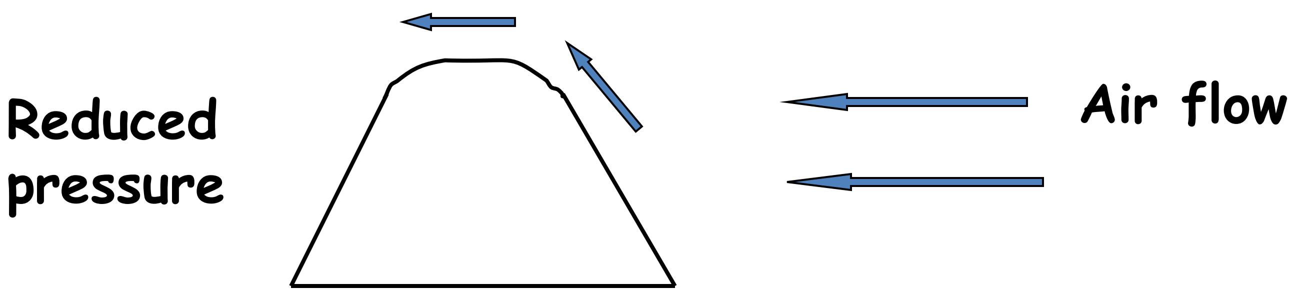
Hydrocarbon impacted soil and/or drilling wastes

Bulking agent

Constructing windrows

Windrow design

- Maximum height 5 – 9 ft to avoid compaction
- Width determined by available mixing equipment
- Steep sloping sides to shed precipitation
- Flattened top to minimize surface area to volume ratio (limit heat loss)



Airplane wing effect causes air to flow through the pile.

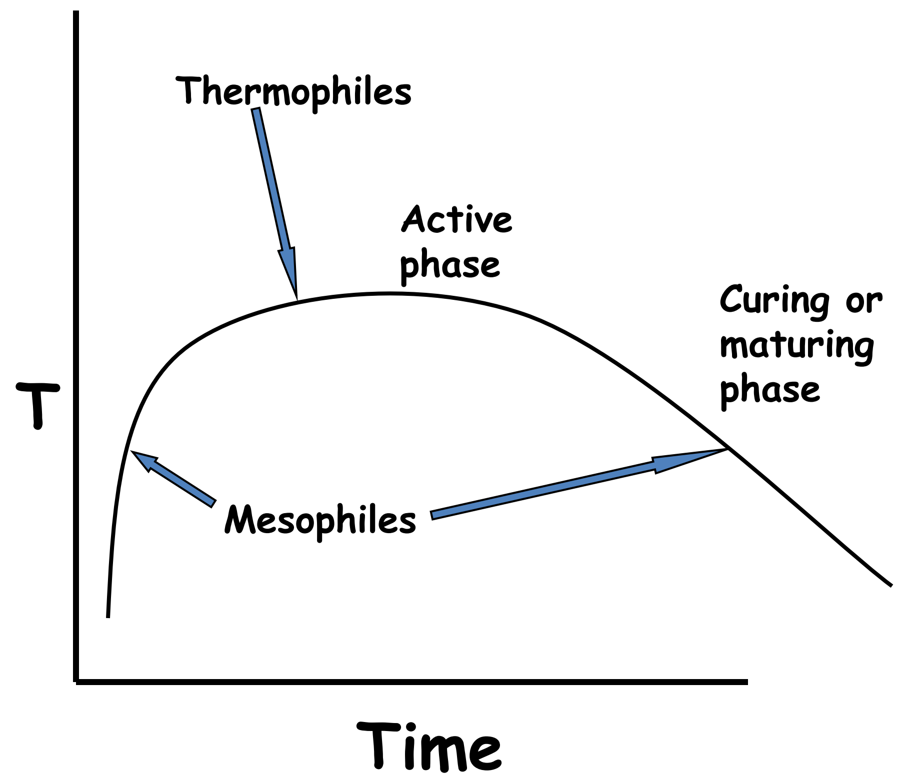
Mixing of windrows

Ideal mixing moves compost from the bottom to the top and vice versa

Temperature

- Composting frequently relies on microbial heating and thermophilic organisms; good for cold climates- can greatly extend treatment season (Has been applied at T as low as -50 ^{o}F)
- Hydrocarbon biodegradation is unlikely to provide enough energy to heat the compost pile, at least not initially. Other more easily biodegraded organics can be added to "kick off the process"
  - municipal sewage sludge
  - molasses
  - grass clippings
  - meat and vegetable wastes

Idealized temperature curve for a composting cycle



Maximum temperature 50 – 55 ^{o}C; Time scale 8 wks to 6 months

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Windrow sampling

Windrow sampling: Gases

What to do with treated compost

Microtox testing

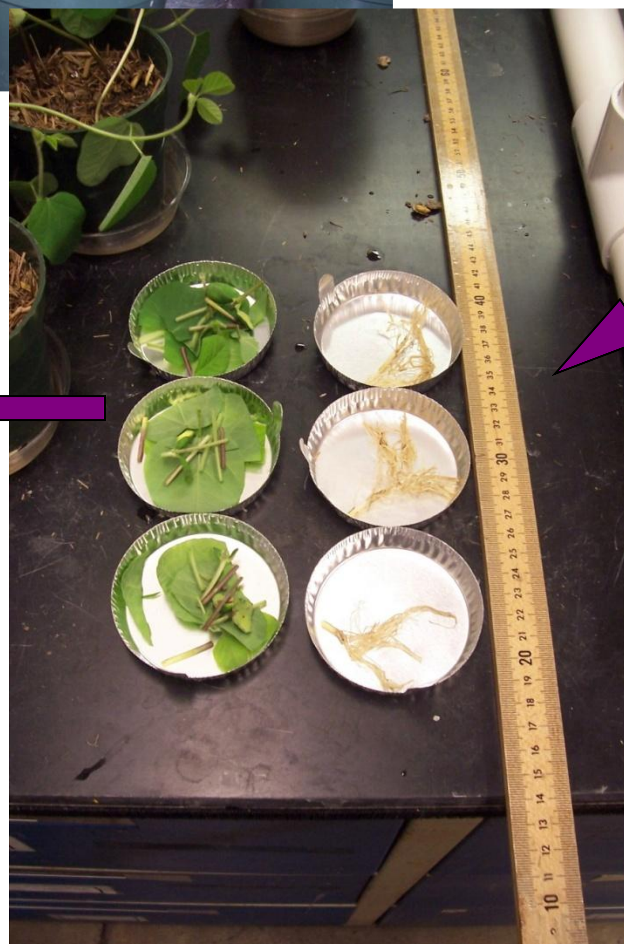
marine
luminescent
bacteria

Seed germination testing


Standard germination in tomato

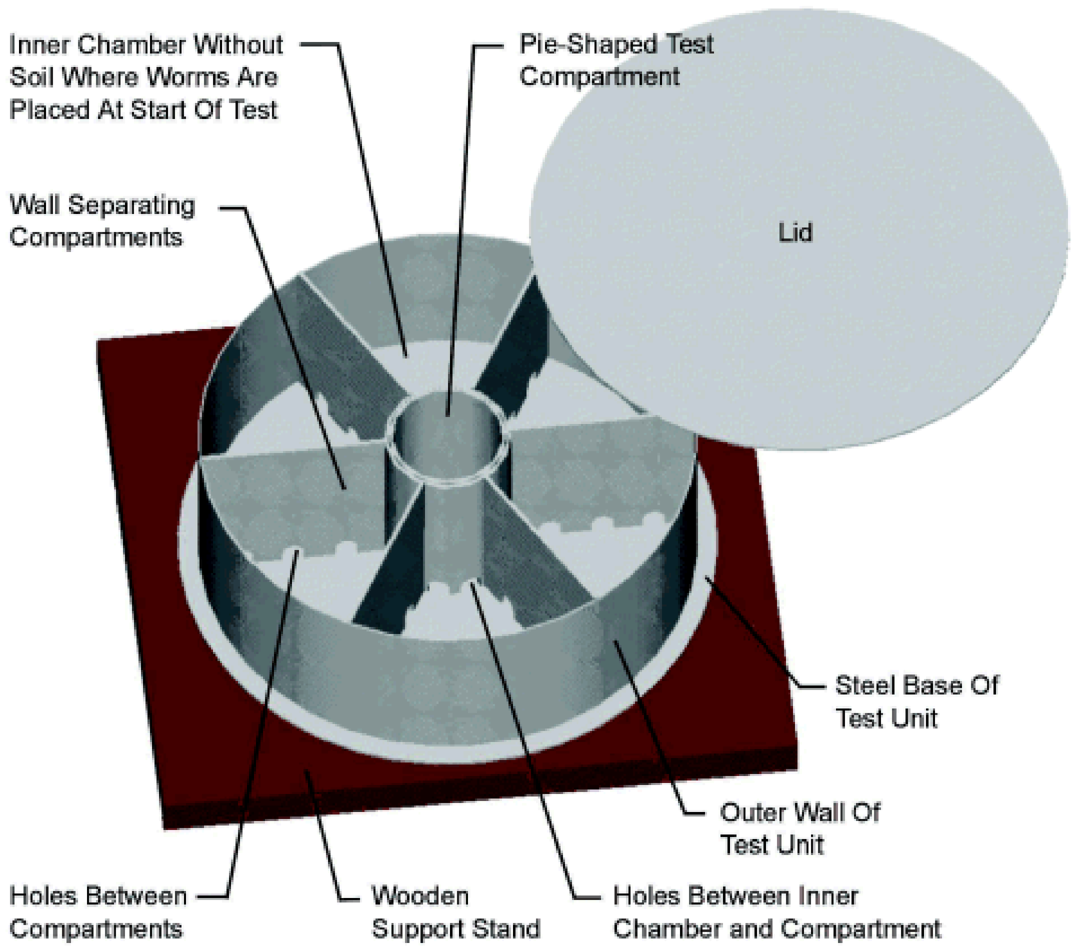
Root elongation testing

General growth characteristics



Dry and weigh

Earthworm avoidance test chamber



Earthworm survivability

Case Study: Biotreatment of tank and pit bottoms - Composting

An earthen pit was used to collect and store tank bottoms and sludges. Composting was chosen as a method to dispose of the tank bottoms and remediate contaminated soil from the pit.

Characterization and biotreatability

- Pit impoundment soil was found to contain 10^8 viable cells/mL of bacteria capable of growing on petroleum sludge vapors as the sole carbon source
- Saw mill waste (readily available near site) was tested as a bulking agent
- Petroleum sludge from the pit was mixed with impoundment soil, bulking agent, and fertilizers and incubated. Number of culturable hydrocarbon-degrading bacteria increased with time

Case Study: Biotreatment of tank and pit bottoms - Composting

Field pilot

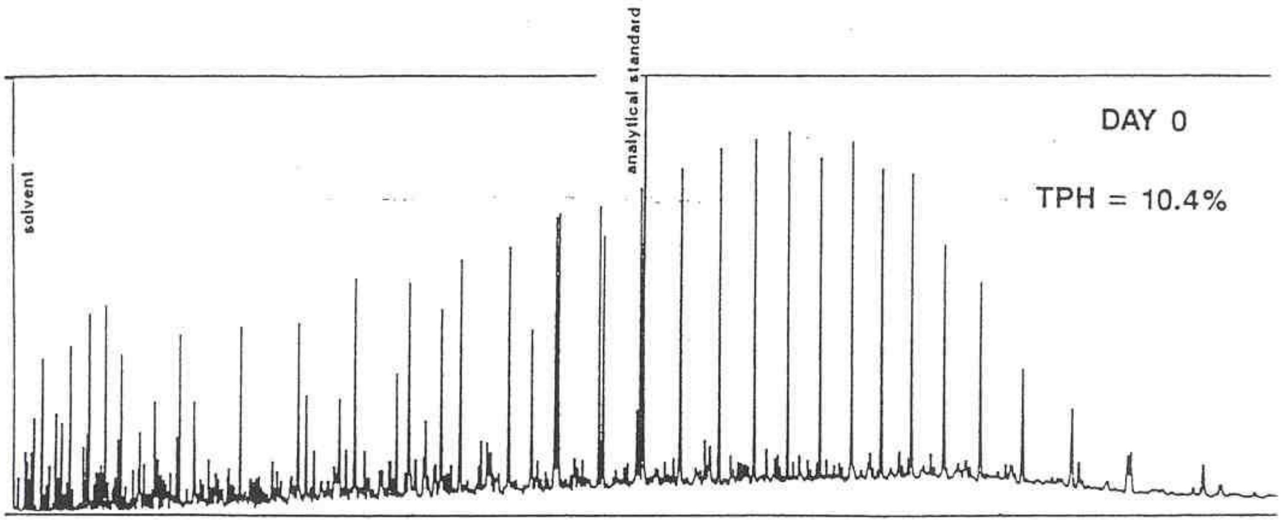
- Bulking agent was laid out in rows on a concrete pad; petroleum sludge from the pit was applied at 20, 30, or 40% volume
- Impoundment soil was added as an inoculum of hydrocarbon-degrading bacteria. Fertilizer and water were applied and mixing was accomplished with tractor-mounted mixing equipment.
- Aerated by tilling 1-2/wk; Water added as needed to maintain a 40% moisture content

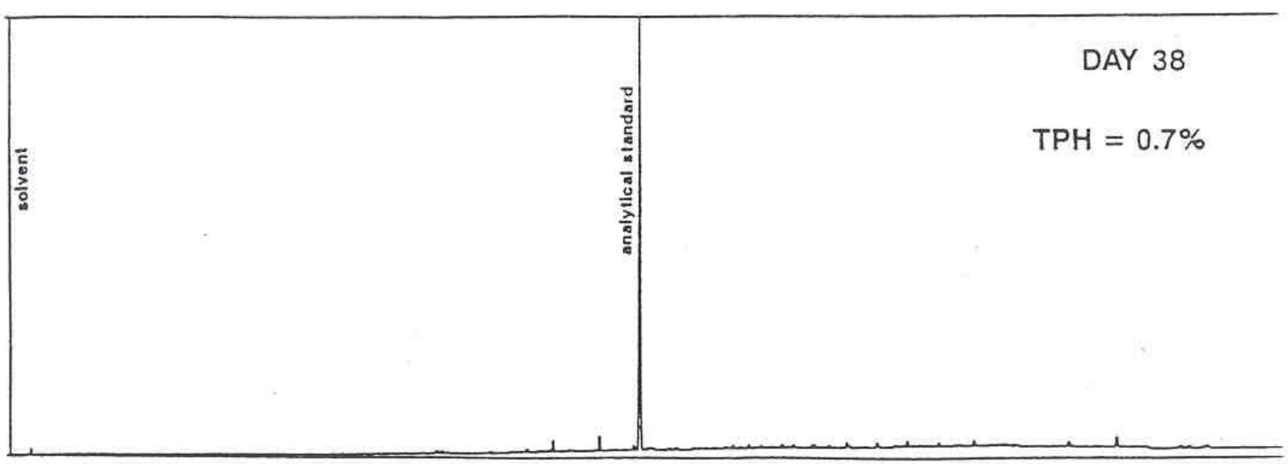
Case Study: Biotreatment of tank and pit bottoms - Composting

- 10-fold composite samples taken each week and analyzed for bioavailable N,P. Fertilizer additions as needed to maintain 50 mg/kg N and 20 mg/kg P
- Temperature measured daily; compost cooled by mixing when temperature exceeds 135 ^{o}F

PETROLEUM HYDROCARBON FINGERPRINTS

REDWASH SLUDGE COMPOST





Decrease in Concentration of Selected Hydrocarbons During Compositing of Petroleum Sludge