TechLink Research Summary #3307

Removal and Degradation of Petroleum Hydrocarbons from Stormwater with Compost

Independent laboratory testing with compost based Filtrexx® FilterMedia™ at the Soil Control Lab in Watsonville, CA has shown that this material can remove petroleum hydrocarbons (as motor oil) from simulated runoff at consistently high percentage rates. Out of 32 independent tests with motor oil concentrations in water between 100 and 1700 mg L-1, compost based filter media removed an average of 87% of the motor oil concentration in stormwater, while 20 of the 32 composts removed greater than 95% of the motor oil concentration in the simulated stormwater runoff.

While compost FilterMedia™ has shown promise to remove petroleum hydrocarbons from stormwater, thereby reducing it's migration to and pollution of ground and surface waters, what is the eventual fate of this pollutant within the compost media?

A benefit of compost is that it can naturally provide, 1) a high diversity of microorganisms including hydrocarbon degrading microorganisms and, 2) an optimum environment for them to thrive. Hydrocarbon degrading microorganisms require an environmental habitat that has a sufficient and preferably sustainable (slow release) source of nutrients (mostly N and P), water, air, mild ambient temperature, and a moderate pH - compost provides a habitat that supplies each of these environmental factors. At optimum levels these environmental factors provide the energy and metabolic resources that create a widely diverse group of beneficial microorganisms that will suddenly reproduce on a very rapid scale. While these degrader microorganisms increase their populations they also work rapidly and effectively to degrade petroleum hydrocarbons, for food (from carbon) to sustain their growth pattern. Additionally, it is often the humus content of compost (6 times higher in mature compost than typical soils) that catalyzes the degradation process of organic compounds/contaminants (Stevenson, 1994 and USEPA, 1998).

Under optimum environmental conditions petroleum concentrations in soil were shown to reduce from 196 to 10 mg kg-1 and from 2109 to 195 mg kg-1 over a one year period (Mohn, 2001). Thomassin-Lacroix et al (2002) found that under favorable environmental conditions diesel fuel was degraded from 2.9 to 0.5 mg g-1 in 65 days, and at a rate of 90 g per gram of soil per day for 14 days. Poultry litter and degrader bacteria degraded 67 - 78% of hydrocarbons in gasoline contaminated soil in 60 days (Rahman et al, 2002). Additionally soils contaminated with oil and treated with nutrients found that slow release nutrient sources produced higher bacteria community structures and higher degradation rates (in the form of CO2 evolution) compared to liquid nutrient sources (Roling et al, 2004). Petroleum contaminated soils amended with compost exhibited degradation rates of 375 mg kg-1/day compared to only 40 mg kg-1/day without compost (Stegmann et al, 1991 and Hupe et al, 1996). At the rate exhibited by the compost amended soil, typical petroleum hydrocarbon contaminated soils (normal range is between 5,000 to 20,000 mg kg-1) would be completely degraded in 14 to 60 days (USEPA, 1998). According to the USEPA (1998) compost has been shown to degrade the following contaminants under controlled conditions and/or in field research programs: petroleum hydrocarbons (gasoline, diesel fuel, jet fuel, oil, grease), polynuclear aromatic hydrocarbons (wood preservatives, refinery wastes, coal gasification wastes), pesticides (herbicides and insecticides), and explosives (TNT, RDX, nitrocellulose).

What is the specific fate of the hydrocarbons after they were degraded by microorganisms (the mass balance for the degraded carbon)?

In an experiment by Hupe et al (1996), 59% was converted to CO2, 4% was volatilized, 4% was converted into the biomass of the microorganisms, 8% was extractable (in its original form), and 24% was bound to residue. The fraction that bonds with the residue often is incorporated into the core structure of the humic materials, making it relatively bio-unavailable for decades and even centuries (Stevenson, 1994 and USEPA, 1998).

Bacteria and Fungi are the primary agents for degradation of organic contaminants in soil (Alexander, 1994), and increasing the diversity, population, and community structure can accelerate the degradation of the contaminants

(Cole et al, 1994). Microbial diversity and population density is greatly increased by the addition of compost compared to fertile, productive soils; therefore, bioremediation takes far less time with compost than under natural conditions (Cole et al, 1994 and USEPA, 1998). Normal bacteria populations in fertile soils are approximately 26 million/gram of dry soil, while in compost bacteria populations are approximately 417 million/gram of dry compost. Similarly, fungi populations in fertile soils are approximately 28 thousand/gram dry soil and 155 thousand/gram for dry compost (Cole, 1976 and Cole et al, 1994). Additionally, microbial activity in mature compost can be nearly 40 times greater in compost than in soil (USEPA, 1998). It is no surprise that hydrocarbon degrading microorganisms are often isolated from compost and used to inoculate bioremediation projects (Civilini et al, 1996 and Castaldi et al, 1995).

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