Chapter 18

Management of Soil Biota and Their Processes

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TABLE S18.1 Ratios of nutrients and microbial populations in the 0–7.5 cm soil depth of no-tillage, conventional tillage and conservation reserve program soils

Soil Parameter	NT/CT*	CRP/CT**
Total Carbon	1.25	0.99
Total Nitrogen	1.20	1.10
Microbial Biomass	1.14	1.04
Fungi	1.57	1.59
Aerobic Bacteria	1.41	1.16
Dehydrogenase	1.50	1.40
PMN***	1.35	1.13

*Ratio of no-tillage to conventional tillage values
**Ratio of conservation reserve program to conventional tillage values
***Potentially mineralizable nitrogen

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TABLE S18.2 Examples of bacteria and fungi introduced to improve agricultural productivity, control pests and degrade toxic substances in soil

Example	Microorganism(s)
Plant Growth	*Bradyrhizobia, Mycorrhizae, Azotobacter,* PGPRB[†]
Biological Control	
Plant Pathogens	*Trichoderma, Fusaria, Pseudomonas*
Insects	*Bacillus, Saccharopolyspora*
Weeds	*Colletotrichum, Phytophthora, Sclerotinia, Pseudomonas*
Bio-remediation	
Aromatic hydrocarbons	
Polycyclic	*Stropharia, Sphingomonas*
BTEX (benzene, toluene, ethylbenzene, xylene)	*Bacillus, Cladophialophora,*
	Pseudomonas, Azoarcus
Pesticides	
Carbamates	*Achromobacter, Pseudomonas*
Organophosphates	*Flavobacterium, Pseudomonas*
Pentachlorophenol	*Athrobacter, Mycobacterium*
Triazines	
Heavy metals, radionuclides	*Flavobacterium, Phanerochaete,*
	Klebsiella, Rhodococcus
	Deinococcus, Geobacter, Shewanella

[†]*PGPRB – Plant growth promoting bacteria.*

TABLE S18.3 **Examples of weed biocontrol microorganisms (adapted from Hajek, 2004; Chutia, et al., 2007; Stubbs and Kennedy, 2012)**

Biocontrol organism	Weed Species	Country	Reference
Rusts			
Puccinia chondrilina	*Chondrilla juncea* (skeleton weed)	Australia	Hasan, 1972
Phragmidium violaceum	*Rubus constrictus* (blackberry)	Chile	Hasan, 1988
Cercosporella spp.	*Ageratina riparia* (mistflower)	Hawaii and Jamaica	Trujillo, 2005
Bacteria			
Pseudomonas fluorescens Bf7-9	*Orobanche foetida* (broomrape)	Tunisia	Zermane et al., 2007
Pseudomonas fluorescens	*Raphanus raphanistrum* (wild radish)	Australia	Flores-Vargas & O'Hara, 2006
Pseudomonas spp. *Xanthomonas* spp.	*Aegilops cylindrica* (jointed goatgrass)	Western U.S.	Kennedy & Stubbs, 2007
Pseudomonas trivialis strain X33D	*Bromus diandrus* (great brome)	Tunisia	Mejri et al., 2010
Xanthomonas campestris pv. *poae* (JTP482)	*Poa annua* (annual bluegrass)	Japan	Imaizumi et al., 1999
Fungi			
Alternaria alternata	*Amaranthus retroflexus* (redroot pigweed)	Europe, North America	Lawrie et al., 2002
Ascochyta caulina	*Chenopodium album* (common lambsquarters)	Worldwide	Ghorbani et al., 2002

Continued

TABLE S18.3 Examples of weed biocontrol microorganisms (adapted from Hajek, 2004; Chutia, et al., 2007; Stubbs and Kennedy, 2012)—Cont'd

Biocontrol organism	Weed Species	Country	Reference
Phyllosticta cirsii; Stagonospora cirsii; Alternaria cirsinoxia; Mix of *Phoma destructiva, Phoma hedericola, Mycelia sterilia, Phoma nebulosa, Phomopsis cirsii*	*Cirsium arvense* (Canada thistle)	Temperate regions of northern hemisphere	Evidente et al., 2008; Yuzikhin et al., 2007; Bailey, 2004; Tichich & Doll, 2006; Guske et al., 2004; Leth et al., 2008

TABLE S18.4 C:N ratios of various compost materials

Material	C:N
Activated sludge	6
Grass clippings	12–15
Manure	20–50
Poultry Manure	15
Soil humus	10
Sawdust	200–500
Vegetable waste	12
Wheat straw	80
Wood	400

TABLE S18.5 Environmental conditions influencing biodegradation

Parameters	Condition required for microbial activity	Optimum for oil degradation
Soil moisture	25–28% of water holding capacity	30–90%
Soil pH	5.5–5.8	6.5–8.0
Oxygen content	Aerobic, minimum air filled pore space 10%	10–40%
Nutrient content	N and P	C:N:P = 100:10:1
Temperature (°C)	15–45	20–30
Contaminants	Not too toxic	Hydrocarbon 5–10% of dry wt. of soil
Heavy metals	<2000 ppm	700 ppm
Soil type	Low clay or silt content	

From: Vidali (2001). Bioremediation. An overview. Pure Appl. Chem. **73**, 1163–1172.

TABLE S18.6 Examples of Superfund sites using bioremediation technologies

Site	Treatment	Contaminants
Applied Environmental Services, NY	Bioventing	Volatile organic compounds (VOCs) Semi-volatile organic compounds (SVOCs)
Onalaska Municipal Landfill, WI	Bioventing	VOCs, polyaromatic hydrocarbons (PAHs)
Eielson Air Force Base, AK	Bioventing	VOCs, SVOCs, PAHs
Brown Wood Preserving, FL	Land treatment	PAHs
Vogel Paint & Wax, IA	Land treatment	VOCs
Broderick Wood Products, CO	Land treatment/ Bioventing	SVOCs, PAHs, dioxins
Burlington Northern (Somers), MT	Land treatment	SVOCs, PAHs

From: A Citizen's Guide to Bioremediation (1996). US EPA. Solid Waste and Emergency Response. Technology Innovation Office. Technology Fact Sheet. EPA 542-F-96-007

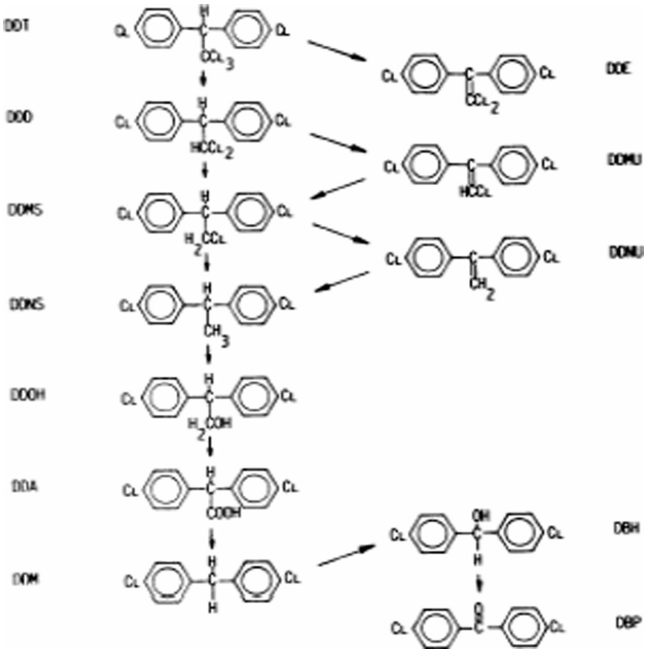

FIG. S18.1 Primary biodegradative pathway for the metabolism of DDT in microorganisms. Abbreviations: DDMS = 1-chloro-2.2-bis(4-chlorophenyl)ethane; DDNS = 2.2-bis(4-chlorophenyl) ethane; DDOH = 2.2-bis(4-chlorophenyl)ethanol; DDA = 2.2-bis(4-chlorophenyl)acetic acid; DDMU = l-chloro-2.2-bis(4-chlorophenyl)ethane; DDNU = 1.1-bis(4-chlorophenyl)ethene. *(From Bumpus and Aust, 1987).*

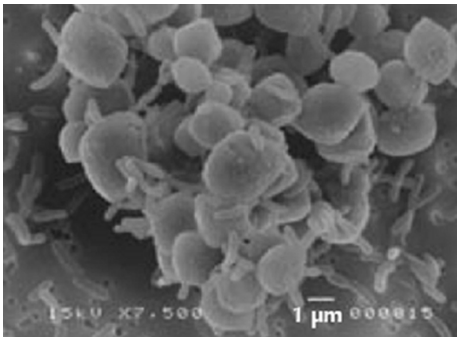

FIG. S18.2 *Geobacter sulfurreducens* is the dominant metal-reducing microorganism isolated from subsurface environments and aquifers. It oxidizes aromatic hydrocarbons with Fe(III) as the electron acceptor. It can also oxidize organic pollutants while reducing other metals such as Mn(IV), U(VI), Te(VII), Co(VI), and Au(III). Image from Bioremediation of Metals and Radionuclides (2003). A NABIR Primer. 2nd Ed. Lawerence Berkeley National Laboratory, U.S. Department of Energy Publication LBNL-42595(2003).