



Front page for deliverables

| | |
|--------------------------|---|
| <i>Project no.</i> | 003956 |
| <i>Project acronym</i> | NOMIRACLE |
| <i>Project title</i> | Novel Methods for Integrated Risk Assessment of Cumulative Stressors in Europe |
| <i>Instrument</i> | IP |
| <i>Thematic Priority</i> | To develop a research framework for the description and interpretation of combined exposure effects that leads to the identification of biomarkers of cumulative exposure and effect |

Deliverable reference number and title:

D. 2.3.6 Report on preparation of electronic database for biodegradation in soil


Due date of deliverable: May 1, 2007, *Actual submission date:* May 7, 2007

Start date of project: 1 November 2004 *Duration:* 5 years

Organisation name of lead contractor for this deliverable: LMC

Revision: draft

| Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006) | | |
|--|---|---|
| Dissemination Level | | |
| PU | Public | X |
| PP | Restricted to other programme participants (including the Commission Services) | |
| RE | Restricted to a group specified by the consortium (including the Commission Services) | |
| CO | Confidential, only for members of the consortium (including the Commission Services) | |

| | | | | |
|--|-------------------|-------------------------|---|----------------------------------|
| Authors and their organisation: Gergana Dimitrova, Danieala Nedelcheva, Sabcho Dimitrov, Ovanes Mekenyan, LMC, Partner 35 | | |  | |
| Deliverable no: D.2.3.6 | Nature: Report | Dissemination level: PU | | Date of delivery: May 1, 2007 |
| Status: Draft | | Date of publishing: | | |
| Reviewed by (period and name): April 2007, Ryszard Laskowski | | | | |

Deliverable reference number and title:

D. 2.3.6 Report on preparation of electronic database for biodegradation in soil

Due date of deliverable: May 1, 2007, Actual submission date: May 7, 2007

D. 2.3.6 Report on preparation of electronic database for biodegradation in soil

Gergana Dimitrova, Danieala Nedelcheva, Sabcho Dimitrov, Ovanes Mekenyan

Laboratory of Mathematical Chemistry, University “Prof. As. Zlatarov”, 8010 Bourgas, Bulgaria

Contents

| | Page |
|--|-------------|
| 1. Glossary | 4 |
| 2. Introduction | 5 |
| 3. Collected data for biodegradability in soil | 5 |
| 3.1. Rate of biodegradation in soil | 5 |
| 3.2. Database with observed biodegradation pathways | 11 |
| 3.3. Behavior in soil and major metabolites | 23 |
| 4. Summary | 27 |
| 5. References | 27 |

1. Glossary

| | |
|------------------|--|
| CASRN | Chemical Abstract Service Registry Number. |
| CO ₂ | Max. amount of CO ₂ production (and time-point) in soil. |
| DT ₅₀ | Time in which 50% of the parent compound has disappeared from soil by transformation. |
| RIVM | National Institute of Public Health and Environmental Protection. |
| SMILES | Simplified Molecular Input Line Entry System. This is a chemical notation system that is used to represent the 2D molecular structure by a linear string of symbols. |

2. Introduction

This report provides an overview of the collected data for biodegradability in soil. All data could be grouped in three types. First type of data includes a set of 219 pesticides with information about the most important properties which describe biodegradability and mobility, such as DT₅₀ and CO₂ production. The second set of data includes 183 chemicals with documented maps for biodegradation in soil. The third set of chemicals includes 20 pesticides having information about the maximum amount of their major metabolites, biodegradability DT₅₀ and observed metabolic maps in soil.

3. Collected data for biodegradability in soil

3.1. Rate of biodegradation in soil

A set of 219 pesticides with biodegradability data were collected from the report provided by the National Institute of Public Health and Environmental Protection (RIVM) [1]. The data mentioned are based on confidential information supplied by the manufactures of the pesticides. Most of the data are derived from laboratory experiments under aerobic conditions with the active ingredient of a pesticide. For some pesticides only data from field studies are available. The collected information for the chemicals includes common name, arithmetic mean or median of DT₅₀ (days), range of variation of DT₅₀, maximum amount of CO₂ calculated as a percentage of the total CO₂ that the chemicals could theoretically produce (ThCO₂ %) and the duration of the test period.

The available information for the pesticides is summarized in Table 1. It should be noted that in the table a dash means that data are not available; data derived from less reliable studies due to inadequate experimental design are marked with an asterisk. 218 out of 219 pesticides have data for DT₅₀, 156 have data for CO₂, and 155 compounds have information for both the DT₅₀ and CO₂.

Table 1. List of pesticides with their rate of biodegradation in soil.

| CASRN | Chemical name | DT ₅₀ (days) mean/median | Range of variation of DT ₅₀ (days) | ThCO ₂ (%) | Test period (days) |
|-------------|------------------------|--|--|--------------------------|--------------------------|
| 542-75-6 | 1,3-dichloropropene | 13 | 2-24 | - | - |
| 94-75-7 | 2,4-D pH < 5 | 8 | 2-14 | 49-83 | 51-150 |
| 74070-46-5 | acлонifen | 71 | 43-99 | 3 | 90-104 |
| 101007-06-1 | acrinathrin | 23 | 9-37 | 32-55 | 120 |
| 15972-60-8 | alachlor | 22 | 14-29 | 5.5-30 | 62-175 |
| 116-06-3 | aldicarb | 2.4 | 1.3-3.5 | 65 | 90 |
| 55635-13-7 | Alloxydim sodium | 20 | 2-38 | 17-23 | 28 |
| 101-05-3 | anilazine | 1 | - | 0.3-1.3 | 28-112 |
| 3337-71-1 | asulam | 24 | 9-39 | <1-3.2 | 56-77 |
| 1912-24-9 | atrazine | 50 | 38-62 | 4-14 | 90-375 |
| 86-50-0 | azinphos-methyl | 52* | - | 5-19 | 222-365 |
| 68038-71-1 | Bacillus thuringiensis | 2.7 | - | 13 | 23 |
| 22781-23-3 | bendiocarb | 28* | 5-63* | 10-42 | 60-62 |
| 17606-31-4 | bensultap | 7 | - | 62-79 | 365 |
| 25057-89-0 | bentazone | 48 | 19-77 | 2 | 60 |
| 8001-54-5 | benzalkonium chloride | - | - | 33 | 64 |
| 82657-04-3 | bifenthrin | 219* | 169-292* | 13-37 | 120-180 |
| 13181-17-4 | bromofenoxim | 73 | 0.7-145 | 29-51 | 210-214 |
| 4824-78-6 | bromophos-ethyl | 8* | 6-10* | - | - |
| 18181-80-1 | bromopropylate | 59* | 47-70* | 44-69 | 180-365 |
| 51249-05-9 | buminafos | 9* | 6-13* | | - |
| 41483-43-6 | bupirimate | 79 | 67-91 | 1-53 | 329-365 |
| 63-25-2 | carbaryl | <14* | - | 3-64 | 28-60 |
| 16118-49-3 | carbetamide | 10 | 5-15 | 47-72 | 82-182 |
| 5234-68-4 | carboxin | 7* | - | - | - |

| | | | | | |
|-------------|---------------------------------|------|----------|--------|---------|
| 13360-45-7 | chlorbromuron | 39* | 18-60* | 5-15 | 60 |
| 470-90-6 | chlorfenvinphos | 36 | - | 16 | 100 |
| 1698-60-8 | chloridazon | 31 | 15-46 | - | - |
| 7003-89-6 | chlormequat | 1.3* | - | - | - |
| 1897-45-6 | chlorothalonil | 10 | - | - | - |
| 15545-48-9 | chlorotoluron | 63 | 42-83 | 0.7 | 120 |
| 1982-47-4 | chloroxuron | 36 | - | 5-29 | 30-168 |
| 101-21-3 | chlorpropham | 40 | 36-44 | 16-28 | 200 |
| 2921-88-2 | chlorpyrifos | 94* | 16-172* | 27-89 | 360 |
| 105512-06-9 | clodinafop-propargyl | 0.6 | - | 49-61 | 336 |
| 74115-24-5 | clofentezine | 39 | 19-59 | 46 | 180 |
| 420-04-2 | cyanamide | 3.5* | 0.4-6.6* | - | - |
| 21725-46-2 | cyanazine | 16* | 13-19* | - | - |
| 1134-23-2 | cycloate | 61* | 9.4-133* | - | - |
| 101205-02-1 | cycloxydim | 1 | - | 2.5-32 | 90 |
| 68359-37-5 | cyfluthrin | 116* | 74-172* | 32-36 | 190 |
| 57966-95-7 | cymoxanil | 0.7 | 0.01-1.3 | 64-75 | 40 |
| 52315-07-8 | cypermethrin (cis) | 90* | 61-119* | 6-69* | 112-175 |
| 52315-07-8 | cypermethrin (trans) | 32* | 22-42* | 6-69* | 112-175 |
| 94361-06-5 | cyproconazole | 110 | - | 40 | 140 |
| 66215-27-8 | cyromazine | 93 | 75-110 | 1-8 | 28-367 |
| 75-99-0 | dalapon | 3.6 | 1-7 | - | - |
| 1596-84-5 | daminozide | 4.5* | 3-4.5* | 75-84* | 14 |
| 533-74-4 | dazomet | <1 | - | - | - |
| 52918-63-5 | deltamethrin | 25 | 18-30 | 26-73 | 64-128 |
| 17040-19-6 | demeton-S-methylsulphon | 2.7* | 0.5-5.1* | 10-31 | 73 |
| 13684-56-5 | desmedipham | 49 | 8-101 | 27-50 | 100-448 |
| 1014-69-3 | desmetryn | 9 | 8-10 | 1.2-20 | 30-168 |
| 333-41-5 | diazinon | 21 | 10-31 | 35-56 | 140-166 |
| 1918-00-9 | dicamba | 48 | 5-91 | 2-45 | 70-189 |
| 1194-65-6 | dichlobenil | 70* | 24-116* | 6.1 | 110 |
| 97-17-6 | dichlofenthion | 6* | 4-9* | - | - |
| 1085-98-9 | dichlofluanid | 2.9* | 2.3-3.5* | 78-99 | 63 |
| 120-36-5 | dichlorprop | 15 | 10-20 | - | - |
| 15165-67-0 | dichlorprop-P | 15 | 10-20 | - | - |
| 62-73-7 | dichlorvos | 2 | 1-2 | 60-80 | 1-60 |
| 99-30-9 | dicloran | 282 | - | 8 | 360 |
| 115-32-2 | dicofol op | 15* | - | - | - |
| 7173-51-5 | dodecyldimethylammoniumchloride | 23 | 14-31 | - | - |
| 38727-55-8 | diethyl-ethyl | 114* | 98-131* | 4 | 56 |
| 87130-20-9 | diethofencarb | 5.4 | 1.5-9.2 | 31-57 | 270 |
| 119446-68-3 | difenoconazole | 140 | - | 4 | 107 |
| 14214-32-5 | difenoxuron | 18 | - | 17-29 | 30-168 |
| 35367-38-5 | diflubenzuron | 3 | 2-4 | 26 | 28 |

| | | | | | |
|-------------|-----------------------------------|------|-----------|---------|---------|
| 83164-33-4 | diflufenican | 192 | 116-277 | 46 | 365 |
| 52508-35-7 | dikegulac-sodium | >195 | - | - | - |
| 34205-21-5 | dimefuron | 170* | - | - | - |
| 60-51-5 | dimethoate | 16 | 10-21 | 20-30 | 7-30 |
| 110488-70-5 | dimethomorph (E-isomer) | 41 | - | 17-28 | 362-365 |
| 1420-07-1 | dinoterb | 9.8 | 9.2-10.4 | 23-24 | 50-63 |
| 3347-22-6 | dithianon | 5* | 5-9* | 14-16 | 98 |
| 330-54-1 | diuron | 94* | 79-108* | 3-18 | 40-105 |
| 534-52-1 | DNOC | 8.5 | 4-13 | 11-65 | 59-80 |
| 1593-77-7 | dodemorph | 190* | 152-228* | - | - |
| 759-94-4 | EPTC | 47* | 42-52* | - | - |
| 16672-87-0 | ethephon | 1* | - | 0.06 | 98 |
| 29973-13-5 | ethiofencarb | 37* | 34-131* | 43 | 82 |
| 26225-79-6 | ethofumesate | 37 | - | 38 | 316 |
| 13194-48-4 | ethoprophos | 32 | 8-56 | 56-60 | 90 |
| 80844-07-1 | etofenprox | 11* | 10-11* | 38 | 56 |
| 2593-15-9 | etridiazole | 23* | 12-33* | 6-29 | 10-42 |
| 38260-54-7 | etrimfos | 12.5 | 8-17 | 25-60 | 70 |
| 140-56-7 | fenaminosulf | 17* | - | - | - |
| 22224-92-6 | fenamiphos | 21 | 14-28 | 0.4-39 | 35-180 |
| 103112-35-2 | fenchlorazole-ethyl | 2.4 | 1.6-3.1 | 0.4-0.9 | 97 |
| 122-14-5 | fenitrothion | 28 | 14-42 | 12-70 | 60-365 |
| 66441-23-4 | fenoxaprop-ethyl | <1 | - | 1.4-55 | 10-64 |
| 71283-80-2 | fenoxaprop-P-ethyl | 0.65 | 0.6-0.7 | 10-33 | 100 |
| 74738-17-3 | fenpiclonil | 308* | 210-458* | 27-45 | 270-365 |
| 39515-41-8 | fenpropathrin | 34 | 13-54 | 38-55 | 60-168 |
| 67306-00-7 | fenpropidin | 111 | 73-149 | 50-67 | 180 |
| 67564-91-4 | fenpropimorph | 67* | 16-145* | 9-18 | 45 |
| 900-95-8 | fentin acetate | 46* | 29-62* | 27-75 | 63-280 |
| 76-87-9 | fentin hydroxide | 26* | 5-53* | - | - |
| 51630-58-1 | fenvalerate | 83 | 30-135 | 4-48 | 30-90 |
| 79622-59-6 | fluazinam | 107 | 48-165 | 6 | 361 |
| 113036-88-7 | flucycloxuron | 208 | 146-269 | 21-39 | 175-364 |
| 69377-81-7 | fluroxypyr | 2.4 | - | - | - |
| 81406-37-3 | fluroxypyr 1-methylheptyl ester | 27 | - | 47-76 | 365 |
| 85509-19-9 | flusilazole | 600* | - | 0.2-1.1 | 365 |
| 66332-96-5 | flutolanil | 601* | 445-712* | 0.4-6 | 180 |
| 69409-94-5 | fluvalinate | 7* | 4-10* | 3-9 | 56 |
| 944-22-9 | fonofos | 99* | 48-150* | - | - |
| 2540-82-1 | formothion | <1 | - | 55-75 | 60 |
| 39148-24-8 | fosetyl-aluminium | 0.07 | 0.03-0.11 | 70-75 | 4 |
| 65907-30-4 | furathiocarb | 1* | - | 52 | 365 |
| 81591-81-3 | glyphosate-trimesium (glyph.part) | 8* | - | 83 | 376 |
| 81591-81-3 | glyphosate-trimesium (trim.part) | 4* | - | 75 | 211 |

| | | | | | |
|-------------|----------------------------------|---------|-------------|---------|---------|
| 108173-90-6 | guazatine | 20* | - | 28-45 | 190-454 |
| 87237-48-7 | haloxyfop ethoxyethyl | 1.5 | - | 33-36 | 180 |
| 23560-59-0 | heptenophos | 0.7 | 0.07-1.8 | 27-48 | 7 |
| 79983-71-4 | hexaconazole | 122 | 49-200 | 13-39 | 280 |
| 51235-04-2 | hexazinone | 62 | 59-64 | 35 | 175 |
| 81405-85-8 | imazamethabenz-methyl (m-isomer) | 51 | 45-57 | 11-58 | 240-360 |
| 81334-34-1 | imazapyr | 510* | - | 14 | 360 |
| 138261-41-3 | imidacloprid | 180 | 159-200 | 6-10 | 100 |
| 36734-19-7 | iprodione | 41 | - | 9-14 | 385 |
| 25311-71-1 | isofenphos | 64* | 40-88* | 10 | 92 |
| 82558-50-7 | isoxaben | 262* | 165-389* | 12-15 | 252 |
| 91465-08-6 | lambda-cyhalothrin | 41 | 13-69 | 36-70 | 92-181 |
| 2164-081 | lenacil | 179 | - | 47 | 365 |
| 58-89-9 | lindane | 1406 | - | 5 | 336 |
| 330-55-2 | linuron | 131 | 47-236 | 2.6-3 | 180 |
| 8018-017 | mancozeb | 5 | 3-7 | - | - |
| 12427-38-2 | maneb | f 56 | - | - | - |
| 94-74-6 | MCPA | 15 | 6-24 | - | - |
| 7085-19-0 | mecoprop | 11 | 6-14 | - | - |
| 16484-77-8 | mecoprop-P | 11 | 6-14 | - | - |
| 57837-19-1 | metalaxyl | 42 | 29-54 | 14-25 | 180-360 |
| 108-62-3 | metaldehyde | 10* | 9-12* | 13 | 91 |
| 41394-05-2 | metamitron | 30 | 20-40 | 28-33 | 84-470 |
| 137-42-8 | metam-sodium | 0.009 | 0.003-0.018 | - | - |
| 67129-08-2 | metazachlor | 18 | 10-27 | - | - |
| 18691-97-9 | methabenzthiazuron | 135 | 117-153 | 0.2-6.6 | 77-126 |
| 10265-92-6 | methamidophos | 2.6 | 1.2-4 | - | - |
| 950-37-8 | methidathion | 4.5 | - | 14-61 | 28-365 |
| 2032-65-7 | methiocarb | 61* | 42-80* | - | - |
| 16752-77-5 | methomyl | 8 | 2-14 | 30-45 | 40 |
| 74-83-9 | methyl bromide | 15* | 1-29* | - | - |
| 556-61-6 | methyl isothiocyanate | 6 | 4-8 | - | - |
| 9006-42-2 | metiram | 6* | 0.05-12* | - | - |
| 51218-45-2 | metolachlor | 101 | 59-144 | 5-7 | 84-112 |
| 19937-59-8 | metoxuron | f 18.5* | f 16-21* | - | - |
| 74223-64-6 | metsulfuron-methyl | 31 | 27-34 | 36 | 168 |
| 26718-65-0 | mevinphos | 1.2* | 0.4-2* | - | - |
| 1746-81-2 | monolinuron | 50 | 33-66 | 9-54 | 112 |
| 88671-89-0 | myclobutanil | 282* | 200-393" | 3-28 | 240 |
| 10552-74-6 | nitrothal-isopropyl | 4* | 1.2-9* | 15-53 | 44-45 |
| 63284-71-9 | nuarimol | 306 | 213-399 | - | - |
| 1113-02-6 | omethoate | 1 | 0.9-1.2 | 19-49 | 49-112 |
| 23135-22-0 | oxamyl | 18* | 10-26* | 51-59 | 28-42 |
| 301-12-2 | oxydemeton-methyl | 0.5 | - | 59-79 | 57-60 |
| 56-38-2 | parathion | 49 | 18-92 | 40 | 135 |

| | | | | | |
|-------------|-----------------------------|------|-----------|----------|---------|
| 298-00-0 | parathion-methyl | 19 | 14-23 | 60 | 135 |
| 66246-88-6 | penconazole | 197 | 194-200 | 1.4-65 | 364-546 |
| 66063-05-6 | pencycuron | 64* | 42-86* | 12-26 | 60 |
| 40487-42-1 | pendimethalin | 171 | 129-207 | - | - |
| 52645-53-1 | permethrin | 13 | - | 2-83 | 28-84 |
| 13684-63-4 | phenmedipham | 45* | 16-74* | 8-35 | 224-365 |
| 2310-17-0 | phosalone | 7 | 4.6-9.4 | 7-10 | 29-85 |
| 732-11-6 | phosmet | 5.6* | 3.4-7* | 53-80 | 308 |
| 13171-21-6 | phosphamidon | 4.5* | 0.8-5.3* | 80 | 66 |
| 51-03-6 | piperonyl butoxide | 13* | 12-14* | - | - |
| 23103-98-2 | pirimicarb | 108 | 8-222 | 0.5-97 | 84-490 |
| 29232-93-7 | pirimiphos-methyl | 12.5 | 12-13 | 1-17 | 210 |
| 7287-19-6 | prometryn | 41 | 37-45 | 0-6 | 180-360 |
| 1918-16-7 | propachlor | 5.2 | 3.4-7.0 | 0.5-13 | 98-126 |
| 24579-73-5 | propamocarb | 25 | 16-38 | 49-95 | 31-360 |
| 111479-05-1 | propaquizafop | 10 | - | 33-40 | 360 |
| 139-40-2 | propazine | 132 | 92-157 | 1-9 | 225-364 |
| 122-42-9 | propham | 11 | 6-15 | 25-40 | 200 |
| 60207-90-1 | propiconazole | 96* | 67-125* | 3 | 364 |
| 114-26-1 | propoxur | 79 | 26-131 | 20-35 | 330 |
| 23950-58-5 | propyzamide | 25 | 12-37 | - | - |
| 52888-80-9 | prosulfocarb | 24 | 9-39 | 52 | 370 |
| 13457-18-6 | pyrazophos | 39* | 23-53* | 14 | 77 |
| 8003-34-7 | pyrethrins | 8* | 6-10* | - | - |
| 96489-71-3 | pyridaben | 55 | 26-84 | 21 -50 | 360 |
| 55512-33-9 | pyridate | 5* | 3.5-6* | 13-25 | 70 |
| 88283-41-4 | pyrifenoxy | 66 | 60-72 | 5-16 | 365 |
| 90717-03-6 | quinmerac | 68 | 35-101 | 0.8-30 | 31-365 |
| 76578-14-8 | quizalofop-ethyl | 0.3 | 0.26-0.35 | 2-10 | 60 |
| 100646-51-3 | quizalofop-P-ethyl | 2* | - | - | - |
| 122931-48-0 | rimsulfuron | 31 | - | 1-6 | 365 |
| 74051-80-2 | sethoxydim | 1.2 | 0.9-1.5 | 1-15 | 30-60 |
| 122-34-9 | simazine | 58 | 31-85 | 8 | 365 |
| 3689-24-5 | sulfotep | 28* | 14-42* | - | - |
| 107534-96-3 | tebuconazole | 652* | 355-841* | 0.7-32 | 433 |
| 79538-32-2 | tefluthrin | 13 | - | 11-65 | 60-180 |
| 3383-96-8 | temephos | <2* | - | - | - |
| 13071-79-9 | terbufos | 8* | 6-11* | 46 | 365 |
| 886-50-0 | terbutryn | 74 | 22-125 | 0.1-18.5 | 28-181 |
| 79277-27-3 | thifensulfuron-methyl | 6 | 3-9 | 31-44 | 140 |
| 31895-22-4 | thiocyclam hydrogen oxalate | 2.2* | 0.5-3.8* | 38-59 | 32 |
| 59669-26-0 | thiodicarb | 2 | 1.5-3 | 64-90 | 35-57 |
| 39196-18-4 | thiofanox | 4 | 2-6 | 75 | 153 |

| | | | | | |
|------------|------------------|------|----------|-------|---------|
| 640-15-3 | thiometon | 2* | 1.9-7* | - | - |
| 137-26-8 | thiram | 18* | 7-35* | - | - |
| 57018-04-9 | tolclofos-methyl | 66 | 45-95 | 19-38 | 90-240 |
| 731-27-1 | tolylfluanid | 1 | 1-1 | 25-40 | 99 |
| 55219-65-3 | triadimenol | 114* | - | - | - |
| 2303-17-5 | tri-allate | 103 | 101-104 | 5-28 | 28-119 |
| 76608-88-3 | triapenthenol | 81* | 65-95* | 31-48 | 196 |
| 24017-47-8 | triazophos | 65* | 27-102* | 6-22 | 21-88 |
| 52-68-6 | trichlorfon | 18* | 7-30* | - | - |
| 55335-06-3 | triclopyr | 20 | 12-27 | 19-20 | 101-300 |
| 24602-86-6 | tridemorph | 34* | 11-56* | 12-23 | 49 |
| 99387-89-0 | triflumizole | 13 | 7-19 | 3-6 | 70-98 |
| 1582-09-8 | trifluralin | 221* | 186-255* | - | - |
| 26644-46-2 | triforine | 19 | 11-27 | 38 | 90 |
| 2275-23-2 | vamidothion | 1.8 | 1.5-2.1 | 9-10 | 14 |
| 50471-44-8 | vinclozolin | 23* | 4-43* | 0.5 | 45 |
| 81-81-2 | warfarin | 5 | - | - | - |
| 137-30-4 | ziram | 40* | - | - | - |

3.2. Database with observed biodegradation pathways

An electronic database with documented biodegradation pathways in soil were collected and entered into the MetaPath database at different levels of completeness. Using MetaPath software (developed under the grant CR-83199501-0 with US EPA, Athens USA) the experimental information on observed metabolites, biotransformations and relative biotransformation rates can be systematically compiled into a searchable database. The created database includes observed biodegradation pathways for 183 chemicals, mainly pesticides which are presented in Table 2. Amongst them there are herbicides, insecticides, fungicides, acaricides, etc. The later includes substances with a variety of chemical functionality, such as acid amides, anilines and nitrobenzenes, dithio and thiolcarbamates, five- and six- membered heterocyclic compounds, phenyl (aryl) carbamates, phosphoro(di)thiolates, sulfonyleureas, etc. All chemicals are tested in soil but for most of them the microbial species are unknown and in these cases in

the database is entered the general name microorganism. For 44 chemicals from the database the microbial species is bacteria and for 25 of them there is an additional information about bacteria species and/or bacteria strain. 46 chemicals from the database have additional information about the conditions of biodegradation (aerobic or anaerobic metabolism).

Table 2. List of chemicals with observed biodegradation pathways.

| Map No. | Study No. | Chemical name | CASRN | References | Study name | Species | Strain | Biotism |
|---------|-----------|--------------------------------|-------------|------------|----------------------|----------------|--------|---------|
| 1 | 1 | Urea | 000057-13-6 | 2 | Soil, Microorganisms | Microorganisms | | |
| 2 | 1 | Isopropylbenzene | 000098-82-8 | 3 | Soil, Microorganisms | Microorganisms | | |
| 3 | 1 | N-Butylbenzene | 000104-51-8 | 3 | Soil, Microorganisms | Microorganisms | | |
| 4 | 1 | Isobutylbenzene | 000538-93-2 | 3 | Soil, Fungi | Fungi | | |
| 5 | 1 | 2-Phenylpentane | 002719-52-0 | 3 | Soil, Fungi | Fungi | | |
| 6 | 1 | 3-Phenylpentane | 001196-58-3 | 3 | Soil, Microorganisms | Microorganisms | | |
| 7 | 1 | Anthracene | 000120-12-7 | 4 | Soil, Microorganisms | Microorganisms | | |
| 8 | 1 | 2,4-Dichlorophenoxyacetic acid | 000094-75-7 | 5 | Soil, Microorganisms | Microorganisms | | |
| 9 | 1 | Permethrin | 052645-53-1 | 6 | Soil, Microorganisms | Microorganisms | | |
| 10 | 1 | Chlorothalonil | 001897-45-6 | 7 | Soil, Microorganisms | Microorganisms | | |
| 11 | 1 | Chlorotoluron | 015545-48-9 | 8 | Soil, Microorganisms | Microorganisms | | |
| 12 | 1 | Chloroacetamide | 000079-07-2 | 9 | Soil, Microorganisms | Microorganisms | | |
| 13 | 1 | Chloroacetonitrile | 000107-14-2 | 9 | Soil, Microorganisms | Microorganisms | | |
| 14 | 1 | Chloroacetic_acid | 000079-11-8 | 9 | Soil, Microorganisms | Microorganisms | | |
| 15 | 1 | Fenamiphos | 022224-92-6 | 10 | Soil, Microorganisms | Microorganisms | | |
| 15 | 2 | Fenamiphos | 022224-92-6 | 10 | Soil, Microorganisms | Microorganisms | | |
| 15 | 3 | Fenamiphos | 022224-92-6 | 10 | Soil, Microorganisms | Microorganisms | | |
| 16 | 1 | Pentachloronitrobenzene | 000082-68-8 | 11 | Soil, Microorganisms | Microorganisms | | |
| 17 | 1 | Carbaryl | 000063-25-2 | 12 | Soil, Microorganisms | Microorganisms | | |
| 18 | 1 | Pendimethalin | 040487-42-1 | 13 | Soil, Microorganisms | Microorganisms | | |
| 18 | 2 | Pendimethalin | 040487-42-1 | 13 | Soil, Microorganisms | Microorganisms | | |
| 18 | 3 | Pendimethalin | 040487-42-1 | 13 | Soil, Microorganisms | Microorganisms | | |
| 19 | 1 | Bromuconazole | 116255-48-2 | 14 | Soil, Microorganisms | Microorganisms | | |
| 20 | 1 | Fenbuconazole | 114369-43-6 | 14 | Soil, Microorganisms | Microorganisms | | |
| 21 | 1 | Flusilazole | 085509-19-9 | 14 | Soil, Fungi | Fungi | | |
| 22 | 1 | Imazalil | 035554-44-0 | 14 | Soil, Microorganisms | Microorganisms | | |
| 23 | 1 | Acetonitrile | 000075-05-8 | 9 | Soil, Microorganisms | Microorganisms | | |
| 24 | 1 | Diphenylamine | 000122-39-4 | 15 | Soil, Microorganisms | Microorganisms | | |

| | | | | | | | | |
|----|---|--|-------------|----|----------------------|--------------------|--|--|
| 25 | 1 | Kerb | 023950-58-5 | 16 | Soil, Microorganisms | Microorganisms | | |
| 26 | 1 | MT-101 | 052570-16-8 | 16 | Soil, Microorganisms | Microorganisms | | |
| 27 | 1 | Chloroanisidine | 005345-54-0 | 16 | Soil, Microorganisms | Microorganisms | | |
| 28 | 1 | Alachlor | 015972-60-8 | 16 | Soil, Microorganisms | Microorganisms | | |
| 29 | 1 | N-sec-Butyl-4-tert-butyl-2,6-dinitroaniline | 033629-47-9 | 16 | Soil, Microorganisms | Microorganisms | | |
| 30 | 1 | Chloronitrofen | 001836-77-7 | 16 | Soil, Microorganisms | Microorganisms | | |
| 31 | 1 | Ethylene_bis-dithiocarbamic_acid | 000111-54-6 | 16 | Soil, Microorganisms | Microorganisms | | |
| 32 | 1 | Benthiocarb | 028249-77-6 | 16 | Soil, Microorganisms | Microorganisms | | |
| 33 | 1 | Molinate | 002212-67-1 | 16 | Soil, Microorganisms | Microorganisms | | |
| 34 | 1 | 3-(3,5-Dichlorophenyl)-5,5-dimethyl-2,4-oxazolidinedione | 024201-58-9 | 16 | Soil, Microorganisms | Microorganisms | | |
| 35 | 1 | Oxadiazone | 019666-30-9 | 16 | Soil, Microorganisms | Microorganisms | | |
| 36 | 1 | Procymidone | 032809-16-8 | 16 | Soil, Microorganisms | Microorganisms | | |
| 37 | 1 | BPMC | 003766-81-2 | 16 | Soil, Microorganisms | Microorganisms | | |
| 38 | 1 | Fluoroimide | 041205-21-4 | 16 | Soil, Microorganisms | Microorganisms | | |
| 39 | 1 | Thiofanox | 039196-18-4 | 16 | Soil, Microorganisms | Microorganisms | | |
| 40 | 1 | Dichlorfop-methyl | 051338-27-3 | 16 | Soil, Microorganisms | Microorganisms | | |
| 41 | 1 | Isothiazolinone | 002682-20-4 | 16 | Soil, Microorganisms | Microorganisms | | |
| 42 | 1 | Thiophanate_methyl | 023564-05-8 | 16 | Soil, Microorganisms | Microorganisms | | |
| 43 | 1 | Methabenzthiazuron | 018691-97-9 | 16 | Soil, Microorganisms | Microorganisms | | |
| 44 | 1 | MIPC | 002631-40-5 | 16 | Soil, Microorganisms | Microorganisms | | |
| 45 | 1 | M-(1-methylbutyl)phenyl_methyl_carbamate | 002282-34-0 | 16 | Soil, Microorganisms | Microorganisms | | |
| 46 | 1 | M-(1-ethylpropyl)phenyl_methyl_carbamate | 000672-04-8 | 16 | Soil, Microorganisms | Microorganisms | | |
| 47 | 1 | Clearcide | 033439-45-1 | 16 | Soil, Microorganisms | Microorganisms | | |
| 48 | 1 | Carpropamid | 104030-54-8 | 17 | Soil, Microorganisms | Microorganisms | | |
| 49 | 1 | Buturon | 003766-60-7 | 16 | Soil, Fungi | Rhizoctonia solani | | |
| 50 | 1 | Dyfonate | 000944-22-9 | 16 | Soil, Microorganisms | Microorganisms | | |
| 51 | 1 | Surecide | 013067-93-1 | 16 | Soil, Microorganisms | Microorganisms | | |
| 52 | 1 | Cyanox | 002636-26-2 | 16 | Soil, Microorganisms | Microorganisms | | |
| 53 | 1 | BAY-NTN-9306 | 035400-43-2 | 16 | Soil, Microorganisms | Microorganisms | | |

| | | | | | | | | |
|----|---|--------------------------------|-------------|----|----------------------|-------------------------------|---------------|-----------|
| 54 | 1 | Supracide | 000950-37-8 | 16 | Soil, Microorganisms | Microorganisms | | |
| 55 | 1 | Phosalone | 002310-17-0 | 16 | Soil, Microorganisms | Microorganisms | | |
| 56 | 1 | Cypermethrins_(cis, trans) | 052315-07-8 | 16 | Soil, Microorganisms | Microorganisms | | |
| 57 | 1 | Sencor | 021087-64-9 | 16 | Soil, Microorganisms | Microorganisms | | |
| 58 | 1 | 3,6-Dichloro-alfa-picolic_acid | 001702-17-6 | 16 | Soil, Microorganisms | Microorganisms | | Aerobic |
| 59 | 1 | Chloroneb | 002675-77-6 | 16 | Soil, Microorganisms | Microorganisms | | |
| 60 | 1 | Metazachlor | 067129-08-2 | 17 | Soil, Bacteria | Bacillus | | |
| 61 | 1 | Thenylchlor | 096491-05-3 | 17 | Soil, Fungi | Fungi | | Aerobic |
| 62 | 1 | Haloxypop-methyl | 069806-40-2 | 17 | Soil, Fungi | Fungi | | Anaerobic |
| 63 | 1 | 1,3-Dichloropropene | 000542-75-6 | 17 | Soil, Bacteria | Bacteria | | |
| 64 | 1 | Carbetamide | 016118-49-3 | 17 | Soil, Microorganisms | Microorganisms | | Aerobic |
| 65 | 1 | Diethofencarb | 087130-20-9 | 17 | Soil, Bacteria | Nocardiosis sp. | | |
| 66 | 1 | Fenothiocarb | 062850-32-2 | 17 | Soil, Microorganisms | Microorganisms | | Aerobic |
| 67 | 1 | Fenothiocarb_sulfoxide | 103614-75-1 | 17 | Soil, Bacteria | Arthrobacter atrocyaneus | MCM B- 425 | |
| 68 | 1 | Orbencarb | 034622-58-7 | 17 | Soil, Bacteria | Bacillus megaterium | MCM B- 423 | |
| 69 | 1 | Fenpyroximate | 134098-61-6 | 17 | Soil, Bacteria | Bacillus sp. | | Aerobic |
| 70 | 1 | Imidacloprid | 105827-78-9 | 17 | Soil, Bacteria | Methylosinus trichosporium | OB-3B | |
| 71 | 1 | Pyrazolate | 058011-68-0 | 17 | Soil, Bacteria | Methylosinus trichosporium | OB-3B | |
| 72 | 1 | Spiroxamine | 118134-30-8 | 17 | Soil, Bacteria | Methylosinus trichosporium | OB-3B | |
| 73 | 1 | Cloransulam-methyl | 147150-35-4 | 17 | Soil, Microorganisms | Methylosinus trichosporium | OB-3B | |
| 74 | 1 | Buprofezin | 069327-76-0 | 17 | Soil, Microorganisms | Microorganisms | | |
| 75 | 1 | Mepanipyrim | 110235-47-7 | 17 | Soil, Bacteria | Streptomyces sp. | D7 | |
| 76 | 1 | Chlorbromuron | 013360-45-7 | 17 | Soil, Microorganisms | Microorganisms | | |
| 77 | 1 | Pencycuron | 066063-05-6 | 17 | Soil, Microorganisms | Microorganisms | | |
| 78 | 1 | Amido-sulfuron | 120923-37-7 | 17 | Soil, Bacteria | Delftia acidovorans | WDL34 | |

| | | | | | | | | |
|-----|---|------------------------------|-------------|----|----------------------|-------------------------|------|---------------------|
| 79 | 1 | Bensulfuron_methyl | 083055-99-6 | 17 | Soil, Microorganisms | Microorganisms | | |
| 80 | 1 | Chlorimuron_ethyl | 090982-32-4 | 17 | Soil, Microorganisms | Microorganisms | | |
| 81 | 1 | Metsulfuron_methyl | 074223-64-6 | 17 | Soil, Microorganisms | Microorganisms | | Aerobic & anaerobic |
| 82 | 1 | Prosulfuron | 094125-34-5 | 18 | Soil, Microorganisms | Microorganisms | | |
| 83 | 1 | Rimsulfuron | 122931-48-0 | 19 | Soil, Bacteria | Bacteria | | |
| 84 | 1 | Thifensulfuron_methyl | 079277-27-3 | 17 | Soil, Microorganisms | Microorganisms | | Aerobic |
| 85 | 1 | Sulfometuron_methyl | 074222-97-2 | 17 | Soil, Microorganisms | Microorganisms | | |
| 86 | 1 | Hexazinone | 051235-04-2 | 20 | Soil, Microorganisms | Microorganisms | | |
| 87 | 1 | Tribenuron_methyl | 101200-48-0 | 17 | Soil, Microorganisms | Microorganisms | | |
| 88 | 1 | Vanilic acid | 000121-34-6 | 21 | Soil, Microorganisms | Microorganisms | | |
| 89 | 1 | Chlorsulfuron | 064902-72-3 | 22 | Soil, Microorganisms | Microorganisms | | |
| 90 | 1 | Trans - Anethole | 004180-23-8 | 23 | Soil, Microorganisms | Microorganisms | | Aerobic & anaerobic |
| 91 | 1 | Clethodim | 099129-21-2 | 24 | Soil, Bacteria | Bacillus brevis | 625 | Aerobic & anaerobic |
| 92 | 1 | Tetradifon | 000116-29-0 | 25 | Soil, Microorganisms | Microorganisms | | |
| 93 | 1 | Chlordimeform | 006164-98-3 | 26 | Soil, Microorganisms | Microorganisms | | Aerobic & anaerobic |
| 94 | 1 | 1,2,3,4-Tetrachlorobenzene | 000634-66-2 | 27 | Soil, Microorganisms | Microorganisms | | Aerobic |
| 95 | 1 | Thiometon | 000640-15-3 | 28 | Soil, Microorganisms | Microorganisms | | Anaerobic |
| 96 | 1 | Bentazone | 025057-89-0 | 29 | Soil, Bacteria | Pseudomonas acidovorans | M3GY | |
| 97 | 1 | 2-Chloroethylphosphonic_acid | 016672-87-0 | 30 | Soil, Fungi | Fungi | | Aerobic & anaerobic |
| 98 | 1 | Ioxynil | 001689-83-4 | 31 | Soil, Bacteria | Bacteria | | |
| 99 | 1 | Ioxynil octanoate | 003861-47-0 | 32 | Soil, Microorganisms | Microorganisms | | Aerobic |
| 100 | 1 | Trifluralin | 001582-09-8 | 33 | Soil, Microorganisms | Microorganisms | | Aerobic & |

| | | | | | | | | |
|-----|---|--|-------------|----|----------------------|-------------------------|------|---------------------|
| | | | | | | | | anaerobic |
| 100 | 2 | Trifluralin | 001582-09-8 | 33 | Soil, Bacteria | Flavobacterium sp. | | |
| 101 | 1 | Diclosulam | 145701-21-9 | 34 | Soil, Microorganisms | Microorganisms | | Aerobic |
| 102 | 1 | Teflubenzuron | 083121-18-0 | 35 | Soil, Microorganisms | Microorganisms | | Aerobic |
| 103 | 1 | Tebuconazole | 107534-96-3 | 36 | Soil, Bacteria | Acinetobacter sp. | BEM2 | Aerobic |
| 104 | 1 | Dicyclopentadiene | 000077-73-6 | 37 | Soil, Bacteria | Pseudomonas sp. | PEM1 | Aerobic |
| 105 | 1 | Myclobutanil | 088671-89-0 | 38 | Soil, Bacteria | Bacteria | | Aerobic |
| 106 | 1 | Sodium acifluorofen | 062476-59-9 | 39 | Soil, Bacteria | Bacteria | | |
| 107 | 1 | Monocrotophos | 006923-22-4 | 40 | Soil, Bacteria | Bacteria | | |
| 107 | 2 | Monocrotophos | 006923-22-4 | 40 | Soil, Bacteria | Bacteria | | |
| 108 | 1 | Fenpropimorph | 067306-03-0 | 41 | Soil, Microorganisms | Microorganisms | | Aerobic & anaerobic |
| 109 | 1 | Methomyl | 016752-77-5 | 42 | Soil, Bacteria | Bacteria | | |
| 110 | 1 | Benomyl | 017804-35-2 | 43 | Soil, Bacteria | Pseudomonas desmolytica | | |
| 111 | 1 | Spinosyn_A | 131929-60-7 | 44 | Soil, Bacteria | Pseudomonas desmolytica | | |
| 112 | 1 | Aldicarb | 000116-06-3 | 45 | Soil, Bacteria | Pseudomonas desmolytica | | |
| 113 | 1 | Spinosyn_D | 131929-63-0 | 44 | Soil, Bacteria | Pseudomonas desmolytica | | |
| 114 | 1 | Carfentrazone - ethyl | 128639-02-1 | 46 | Soil, Bacteria | Pseudomonas desmolytica | | |
| 115 | 1 | Dimethylammonium_[(4-chloro-o-tolyl)oxy]acetate | 002039-46-5 | 47 | Soil, Bacteria | Pseudomonas sp. | | |
| 116 | 1 | Dimethylammonium_(+)-2-[(4-chloro-o-tolyl)oxy]propionate | 053404-32-3 | 47 | Soil, Microorganisms | Microorganisms | | Aerobic |
| 117 | 1 | Dimethylammonium_3,6-dichloro-2-methoxybenzoate | 002300-66-5 | 47 | Soil, Microorganisms | Microorganisms | | |
| 118 | 1 | Fipronil | 120068-37-3 | 48 | Soil, Bacteria | Bacteria | | Aerobic |

| | | | | | | | | |
|-----|---|--|-------------|----|----------------------|-----------------------------|-------|---------------------------|
| | | | | | | | | & anaerobic |
| 119 | 1 | Linuron | 000330-55-2 | 49 | Soil, Microorganisms | Microorganisms | | Aerobic & anaerobic |
| 120 | 1 | Acetochlor | 034256-82-1 | 50 | Soil, Bacteria | Bacteria | | |
| 121 | 1 | Fluometuron | 002164-17-2 | 50 | Soil, Bacteria | Bacteria | | |
| 122 | 1 | Eptam | 000759-94-4 | 51 | Soil, Microorganisms | Microorganisms | | |
| 123 | 1 | Pebulate | 001114-71-2 | 51 | Soil, Microorganisms | Microorganisms | | |
| 124 | 1 | Diallate | 002303-16-4 | 51 | Soil, Microorganisms | Microorganisms | | |
| 125 | 1 | Triallate | 002303-17-5 | 51 | Soil, Microorganisms | Microorganisms | | |
| 126 | 1 | Bitertanol | 055179-31-2 | 52 | Soil, Microorganisms | Microorganisms | | |
| 127 | 1 | Perchloroethylene | 000127-18-4 | 53 | Soil, Microorganisms | Microorganisms | | |
| 128 | 1 | Hexachlorobenzene | 000118-74-1 | 53 | Soil, Microorganisms | Microorganisms | | |
| 129 | 1 | 1,1-Dichloro-2,2-bis(4-chlorophenyl)ethylene | 000072-55-9 | 54 | Soil, Microorganisms | Microorganisms | | |
| 130 | 1 | Fenitrothion | 000122-14-5 | 55 | Soil, Microorganisms | Microorganisms | | |
| 131 | 1 | N-Dodecyl_benzenesulphonate | N/A | 56 | Soil, Bacteria | Bacteria | | |
| 132 | 1 | Methyl_bromide | 000074-83-9 | 57 | Soil, Bacteria | Arthrobacter oxydans | P52 | |
| 133 | 1 | Methyl_tert-butyl_ether | 001634-04-4 | 58 | Soil, Bacteria | Bacteria | | |
| 134 | 1 | Chlorpyrifos | 002921-88-2 | 45 | Soil, Bacteria | Pseudomonas chlororaphis | RW71 | Aerobic |
| 135 | 1 | Alloxydim sodium | 055635-13-7 | 45 | Soil, Microorganisms | Microorganisms | | Aerobic & anaerobic |
| 136 | 1 | Clodinafop-propargyl | 105512-06-9 | 45 | Soil, Microorganisms | Microorganisms | | Aerobic |
| 137 | 1 | Atrazine | 001912-24-9 | 59 | Soil, Microorganisms | Microorganisms | | Aerobic |
| 138 | 1 | Cycloxydim | 101205-02-1 | 45 | Soil, Microorganisms | Microorganisms | | Aerobic |
| 139 | 1 | Dazomet | 000533-74-4 | 60 | Soil, Microorganisms | Microorganisms | | Anaerobic |
| 140 | 1 | Desmedipham | 013684-56-5 | 61 | Soil, Microorganisms | Microorganisms | | |
| 141 | 1 | Metam-Sodium | 000137-42-8 | 62 | Soil, Bacteria | Bacteria | | |
| 142 | 1 | Phenmedipham | 013684-63-4 | 61 | Soil, Bacteria | Bacteria | M91-3 | Aerobic & |

| | | | | | | | | |
|-----|---|----------------------------------|-------------|----|----------------------|------------------------|------|---------------------|
| | | | | | | | | anaerobic |
| 143 | 1 | Metalaxyl | 057837-19-1 | 63 | Soil, Bacteria | Arthrobacter sp. | | Aerobic |
| 144 | 1 | Lufenuron | 103055-07-8 | 64 | Soil, Microorganisms | Microorganisms | | |
| 145 | 1 | 2,6-Dichlorobenzonitrile | 001194-65-6 | 65 | Soil, Microorganisms | Microorganisms | | Aerobic & anaerobic |
| 146 | 1 | Diflubenzuron | 035367-38-5 | 66 | Soil, Microorganisms | Microorganisms | | Aerobic & anaerobic |
| 147 | 1 | Etrifos | 038260-54-7 | 45 | Soil, Microorganisms | Microorganisms | | Aerobic |
| 148 | 1 | Fenoxaprop-ethyl | 066441-23-4 | 67 | Soil, Microorganisms | Microorganisms | | Anaerobic |
| 149 | 1 | Fenoxaprop-P-ethyl | 071283-80-2 | 45 | Soil, Bacteria | Bacteria | | |
| 150 | 1 | Isoxaben | 082558-50-7 | 68 | Soil, Bacteria | Bacteria | | Aerobic & anaerobic |
| 151 | 1 | Phosmet | 000732-11-6 | 69 | Soil, Microorganisms | Microorganisms | | |
| 152 | 1 | Formothion | 002540-82-1 | 70 | Soil, Microorganisms | Microorganisms | | |
| 153 | 1 | LGC-42153 | 412928-75-7 | 71 | Soil, Microorganisms | Microorganisms | | |
| 154 | 1 | 4-Chloroaniline | 000106-47-8 | 72 | Soil, Bacteria | Pseudomonas sp. | | |
| 154 | 2 | 4-Chloroaniline | 000106-47-8 | 72 | Soil, Bacteria | Arthrobacter aurescens | TA13 | |
| 155 | 1 | Furathiocarb | 065907-30-4 | 73 | Soil, Microorganisms | Microorganisms | | |
| 156 | 1 | Glyphosate-trimesium | 081591-81-3 | 45 | Soil, Microorganisms | Microorganisms | | |
| 157 | 1 | Glyphosate | 001071-83-6 | 74 | Soil, Microorganisms | Microorganisms | | |
| 158 | 1 | Glufosinate-ammonium | 077182-82-2 | 75 | Soil, Microorganisms | Microorganisms | | |
| 159 | 1 | Haloxypop-etotyl | 087237-48-7 | 76 | Soil, Microorganisms | Microorganisms | | |
| 159 | 2 | Haloxypop-etotyl | 087237-48-7 | 76 | Soil, Microorganisms | Microorganisms | | Aerobic & anaerobic |
| 160 | 1 | Imazamethabenz-methyl (p-isomer) | 081405-85-8 | 77 | Soil, Bacteria | Bacteria | | |
| 161 | 1 | Imazamethabenz-methyl (m-isomer) | N/A | 77 | Soil, Bacteria | Bacteria | | |
| 162 | 1 | Propaquizafop | 111479-05-1 | 78 | Soil, Microorganisms | Microorganisms | | Aerobic |
| 163 | 1 | Pyridate | 055512-33-9 | 79 | Soil, Microorganisms | Microorganisms | | |

| | | | | | | | |
|-----|---|--------------------|-------------|----|----------------------|------------------|---------------------|
| 163 | 2 | Pyridate | 055512-33-9 | 79 | Soil, Microorganisms | Microorganisms | |
| 164 | 1 | Quizalofop-P-ethyl | 100646-51-3 | 80 | Soil, Microorganisms | Microorganisms | |
| 165 | 1 | Sethoxydim | 074051-80-2 | 81 | Soil, Microorganisms | Microorganisms | |
| 166 | 1 | Fluazifop-P-butyl | 079241-46-6 | 82 | Soil, Microorganisms | Microorganisms | Aerobic & anaerobic |
| 167 | 1 | Acephate | 030560-19-1 | 83 | Soil, Microorganisms | Microorganisms | Aerobic |
| 168 | 1 | Thiodicarb | 059669-26-0 | 84 | Soil, Bacteria | Arthrobacter sp. | Aerobic |
| 168 | 2 | Thiodicarb | 059669-26-0 | 84 | Soil, Microorganisms | Microorganisms | |
| 169 | 1 | Tolylfluanid | 000731-27-1 | 85 | Soil, Microorganisms | Microorganisms | |
| 170 | 1 | Triclopyr | 055335-06-3 | 86 | Soil, Microorganisms | Microorganisms | |
| 171 | 1 | Chlordane | 000057-74-9 | 87 | Soil, Microorganisms | Microorganisms | |
| 172 | 1 | Nitrofen | 001836-75-5 | 88 | Soil, Microorganisms | Microorganisms | Anaerobic |
| 173 | 1 | Diazinon | 000333-41-5 | 89 | Soil, Microorganisms | Microorganisms | Aerobic |
| 174 | 1 | Picolinafen | 137641-05-5 | 90 | Soil, Microorganisms | Microorganisms | Aerobic |
| 175 | 1 | Zoxamide | 156052-68-5 | 91 | Soil, Microorganisms | Microorganisms | Aerobic |
| 175 | 2 | Zoxamide | 156052-68-5 | 91 | Soil, Microorganisms | Microorganisms | |
| 176 | 1 | Flumioxazin | 103361-09-7 | 92 | Soil, Microorganisms | Microorganisms | Anaerobic |
| 177 | 1 | Tebufenozide | 112410-23-8 | 93 | Soil, Microorganisms | Microorganisms | Aerobic |
| 178 | 1 | Tebuthiuron | 034014-18-1 | 94 | Soil, Microorganisms | Microorganisms | Aerobic |
| 178 | 2 | Tebuthiuron | 034014-18-1 | 94 | Soil, Microorganisms | Microorganisms | Aerobic & anaerobic |
| 179 | 1 | Fenvalerate | 051630-58-1 | 95 | Soil, Microorganisms | Microorganisms | Aerobic & anaerobic |
| 180 | 1 | Lactofen | 077501-63-4 | 96 | Soil, Microorganisms | Microorganisms | Aerobic |
| 181 | 1 | Malathion | 000121-75-5 | 97 | Soil, Microorganisms | Microorganisms | |
| 182 | 1 | Propachlor | 001918-16-7 | 98 | Soil, Microorganisms | Microorganisms | |
| 182 | 2 | Propachlor | 001918-16-7 | 98 | Soil, Microorganisms | Microorganisms | Anaerobic |
| 183 | 1 | Norflurazon | 027314-13-2 | 99 | Soil, Microorganisms | Microorganisms | Aerobic |

Information about the chemicals is organized in the following fields:

1. Data fields.

Map information:

- *Map info*
 - Map title
 - References
- *Parent info*
 - Structure, CAS, name, chemical use
 - Test compound
 - IUPAC name
- *Studies*
 - Test subjects (species) – strain
 - Additional information

Chemical information:

- SMILES
- Chemical name + Synonyms
- Chemical use class

Figure 1 represents an example for the documented biodegradation pathway for acetonitrile. On the left the observed metabolic pathway is presented, and on the right part of the window additional information for the chemical is given:

- **reference** – “Castro, Ch. E., S. K. O’Shea, W. Wang, E. W. Bartnicki, Environ. Sci. and Technol., vol. 30, N 4, 1996, pp. 1180-1184”;
- name of the **study** – “Soil, Microorganism”;
- **species** name – “Methylosinus trichosporium”
- **strain** – “OB-3B”.

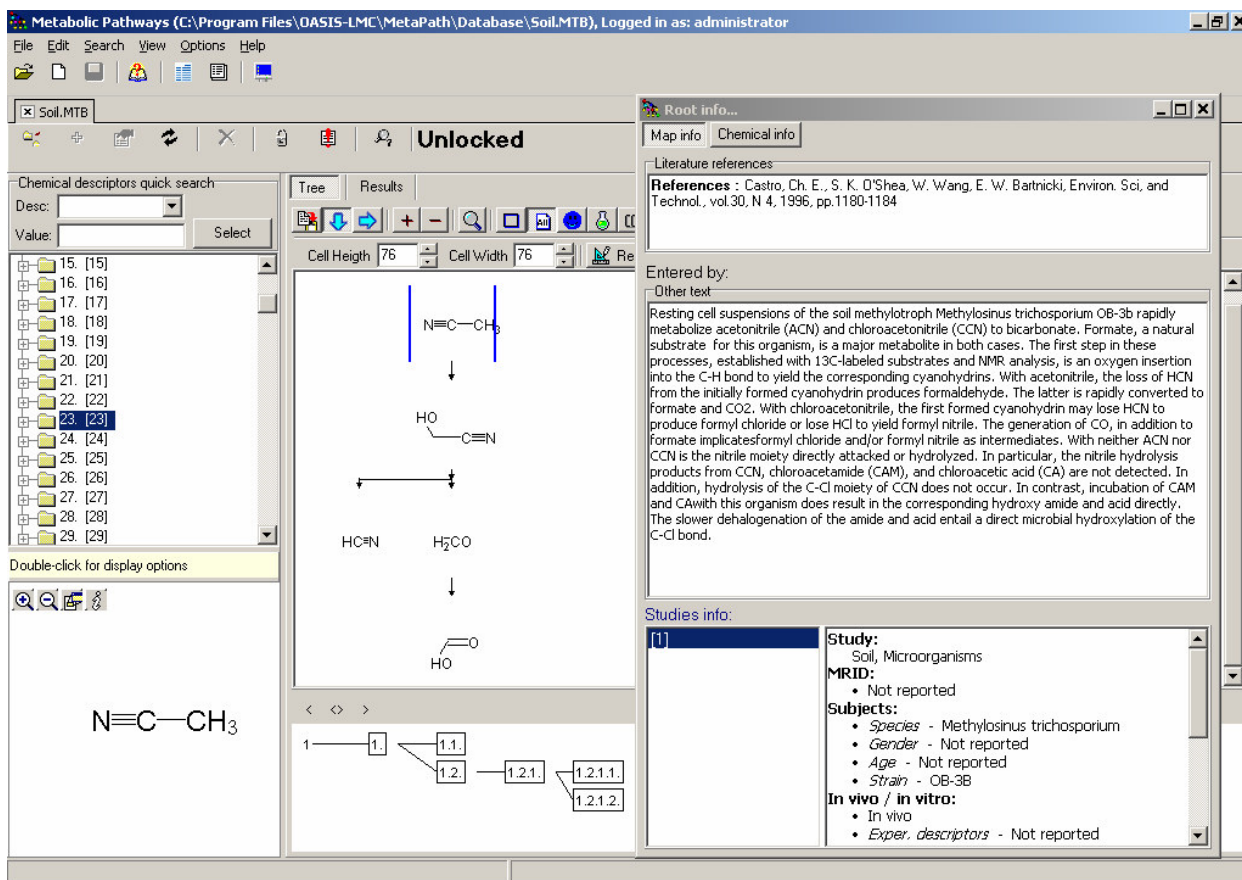


Figure 1. Illustration of the MetaPath file format for documented biodegradation pathway of acetonitrile.

In some cases there are documented metabolic maps including more than one study. This means that for one parent chemical there are metabolites generated by different soil microorganisms and/or at different conditions. In such cases there is a possibility the metabolites from different studies are indicated with different colors as presented on Figure 2. As can be seen from Figure 2, the illustrated metabolic pathway for pendimethalin combines metabolites generated in three studies. The red arrows indicate metabolites generated in the presence of soil

bacteria, while the blue and green arrows indicate metabolites generated in the presence of soil fungi in aerobic and anaerobic conditions, respectively.

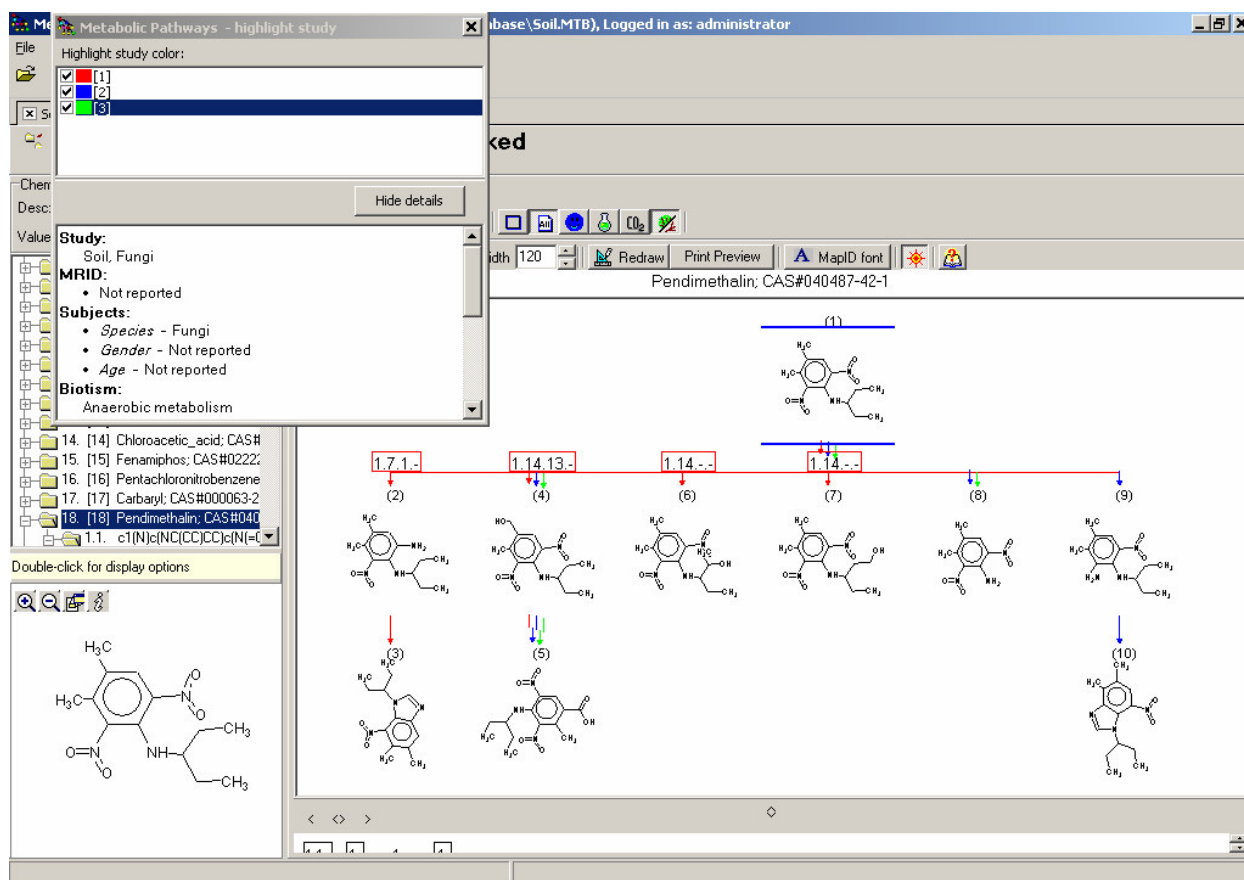


Figure 2. Example of a metabolic pathway including metabolites generated in different study conditions.

3.3. Behavior in soil and major metabolites

For 20 pesticides with documented biodegradation pathways additional data for the amount of their major metabolites and DT_{50} values have been collected. These chemicals are part of the electronic database with observed biodegradation pathways in soil created in MetaPath file format. Information about the time in which 50% of the parent compound has disappeared from

soil was taken from the report provided by the National Institute of Public Health and Environmental Protection (RIVM) [1]. In Table 3 the available data for the 20 pesticides are presented.

Table 3. Major metabolites – behavior in soil.

| Parent chemical | Parent CASRN | Metabolite name | Reference | Study name | Species | Strain | Biotism | Maximum amount, % | DT50 (days) | Test Period (days)? |
|--------------------------|--------------|---|-----------|----------------------|----------------------|--------|---------------------|-------------------|-------------|---------------------|
| Aldicarb | 116-06-3 | Aldicarb sulfoxide | 45 | Soil, Microorganisms | Microorganisms | | | 90 | 22 | 16-28 |
| | | Aldicarb sulfone | 45 | Soil, Microorganisms | Microorganisms | | | 20 | 48 | 9-87 |
| Chlorpyrifos | 2921-88-2 | 3,5,6-trichloro-2-pyridinol | 45 | Soil, Microorganisms | Microorganisms | | | 38 | 91 | 12-217 |
| Alloxydim sodium | 55635-13-7 | methyl 6,6-dimethyl-2-propyl-4-oxo-4,5,6,7-tetrahydrobenzoxazol-5-carboxylate | 45 | Soil, Microorganisms | Microorganisms | | | 10 | 19* | 15-22* |
| Clodinafop-propargyl | 105512-06-9 | clodinafop | 45 | Soil, Microorganisms | Microorganisms | | | 95 | 8* | - |
| Atrazine | 1912-24-9 | desethyl-atrazine | 59 | Soil, Bacteria | Bacteria | M91-3 | Aerobic & anaerobic | 21 | 45* | - |
| | | 2-hydroxy atrazine | 59 | Soil, Bacteria | Bacteria | M91-3 | Aerobic & anaerobic | 33 | 164* | - |
| Cycloxydim | 101205-02-1 | TSO (2-(1-(ethoxyimino)butyl)-3-hydroxy-5-(tetrahydro-2H-thiopyransulfoxide-3-yl)-2-cyclohexen-1-one) | 45 | Soil, Microorganisms | Microorganisms | | | 25* | 45* | - |
| | | T2SO (2-(2*-propyl)oxazolyl-5-(tetrahydro-2-H-thiopyran-3-yl)-2-cyclohexen-1-one) | 45 | Soil, Microorganisms | Microorganisms | | | 25* | 45* | - |
| Dazomet | 533-74-4 | methylisothiocyanate | 60 | Soil, Microorganisms | Microorganisms | | | - | 6 | 4-8 |
| Desmedipham | 13684-56-5 | ethyl-N-(3-hydroxyphenyl)-carbamate | 61 | Soil, Bacteria | Arthrobacter oxydans | P52 | | 49 | 101 | 14-221 |
| Metam-Sodium | 137-42-8 | Methyl isothiocyanate | 62 | Soil, Microorganisms | Microorganisms | | | 48 | 6 | 4-8 |
| Phenmedipham | 13684-63-4 | methyl(3-hydroxyphenyl)-carbamate | 61 | Soil, Bacteria | Bacteria | | | 31 | 56* | - |
| Metalaxyl | 57837-19-1 | N-(2,6-DIMETHYLPHENYL)-N-(2*-RNETHOXYACETYL)ALANINE | 63 | Soil, Bacteria | Bacteria | | | 54 | 58 | - |
| 2,6-Dichlorobenzonitrile | 1194-65-6 | 2.6-Dichlorobenzamide | 65 | Soil, Bacteria | Bacteria | | | 66 | 660* | - |

| | | | | | | | | | | |
|----------------------|------------|--|----|----------------------|------------------|--|---------------------|-----|------|---------|
| Diflubenzuron | 35367-38-5 | 4-chlorophenyl-urea | 66 | Soil, Fungi | Fungi | | Aerobic & anaerobic | 68 | 51* | 37-65* |
| Etrimfos | 38260-54-7 | 6-ethoxy-2-ethyl-4-hydroxypyrimidine | 45 | Soil, Microorganisms | Microorganisms | | | 85 | 98* | 13-186* |
| Fenoxaprop-ethyl | 66441-23-4 | 2-(4-(6-chloro-benzoxazol-2-ylloxy)-phenoxy)propanoic acid | 67 | Soil, Microorganisms | Microorganisms | | | >10 | 12 | 12-13 |
| Fenoxaprop-P-ethyl | 71283-80-2 | Propanoic acid, 2-(4-((6-chloro-2-benzoxazolyl)oxy)phenoxy)-, (R)- | 45 | Soil, Microorganisms | Microorganisms | | | 81 | 16 | 14-18 |
| Isoxaben | 82558-50-7 | N-[3-(1-hydroxy-1-methylpropyl)-5-isoxazolyl]-2,6-dimethoxybenzamide | 68 | Soil, Bacteria | Bacteria | | | 20 | 51* | - |
| Formothion | 2540-82-1 | dimethoate | 70 | Soil, Microorganisms | Microorganisms | | Aerobic & anaerobic | 70 | 16 | 10-21 |
| Furathiocarb | 65907-30-4 | carbofuran | 73 | Soil, Bacteria | Arthrobacter sp. | | Aerobic | 80 | 36 | 16-56 |
| Glyphosate-trimesium | 81591-81-3 | 1-Aminomethylphosphonic acid | 45 | Soil, Microorganisms | Microorganisms | | | 15 | 37 | 26-44 |
| | | Aldicarb sulfone | | | | | | 20 | 48 | 9-87 |
| | | 2-hydroxy-atrazine | | | | | | 33 | 164* | - |
| | | T2SO (2-(2*-propyl)oxazolyl-5-(tetrahydro-2-H-thiopyran-3-yl-2-cyclohexen-1-one) | | | | | | 25* | 45* | - |

4. Summary

Information for biodegradation rate of 219 chemicals, and metabolic fate in soil for 183 chemicals was collected from literature. In progress is the development of an electronic website database that will provide remote access by means of browsing the records as well as creating and executing search queries. The collected biodegradation data will be used for the development of a metabolic simulator for biodegradation in soil.

5. References

1. Pesticides: Benefaction or Pandora's box? A synopsis of the environmental aspects of 243 pesticides. Report no. 679101014.
2. Microbial Degradation of Organic Compounds Microbiology series, v. 13 (Ed. by D. T. Gibson), Marcel Dekker, Inc., N. Y. 1984
3. Microbial Degradation of Organic Compounds Microbiology series, v. 13 (Ed. by D. T. Gibson), Marcel Dekker, Inc., N. Y. 1984, pp. 193-195
4. Microbial Degradation of Organic Compounds Microbiology series, v. 13 (Ed. by D. T. Gibson), Marcel Dekker, Inc., N. Y. 1984, pp. 209-212
5. The University of Minnesota Biocatalysis/Biodegradation Database;
http://umbbd.ahc.umn.edu/2,4-d/2,4-d_map.html; Supplemental Environmental Impact Statement Assessments of Aquatic Herbicides: Volume 3 - 2,4-D, Section 3 - Environmental Fate, pp. 41-48, February 2001; <http://www.24d.org/govtrev/Washington-State-Review.pdf>
6. Spectrum Laboratories, Chemical Fact Sheet: Permethrin (CAS # 52645531);
<http://www.speclab.com/compound/c5264553.htm>

7. Regitano, J. B., V.L.Torniselo, A. Lavorenti, R.S. Pacovsky, Arch. Environ. Contamin. Toxicol., 40(3), 2001, pp.295-302; Chlorothalonil:
<http://www.inchem.org/documents/ehc/ehc//183.htm>
8. Chlorotoluron; <http://www.rsc.org/pdf/general/14chloro.pdf>
9. Castro, Ch. E., S. K. O'Shea, W. Wang, E. W. Bartnicki, Environ. Sci, and Technol., vol.30, N 4, 1996, pp.1180-1184
10. Singh, B.K., W. Allan, M. J. Alun, A. J. W. Mocgan, D. J. Wright, Appl. Environ. Microbiol., 2003, 69 (12), pp. 7035-7043
11. Torres, M., C. Grosset, R. Steiman, J. Alary. Chemosphere, 1996, 33, N 4, pp. 683-692
12. Roberts, T. R., D. H. Hutson, Metabolic Pathways of Agrochemicals, Part 2: Insecticides and Fungicides, Royal Soc. of Chemistry Cambridge, U.K., 1999
13. Aizawa, H., Metabolic Maps: Pesticides, Environmentally Relevant Molecules and Biologically Active Molecules , Academic Press, San Diego, 2001; Reregistration Eligibility Decision, Pendimethalin, EPA 738-R-97-007, June 1997;
<http://www.epa.gov/oppsrrd1/REDs/0187red.pdf>; Kulshrestha, G., S. B. Singh, S. P. Lal, N. T. Yaduraju, Pest Management Science, vol. 56, No 2, 2000,
14. Metabolic Pathways of Agrochemicals, Part 2: Insecticides and Fungicides (Ed. by T.R.Roberts and D.H. Hutson) The Royal Soc. of Chemistry Cambridge, U.K., 1999
15. Drzyzga, O., 2003, Chemosphere, 53
16. Aizawa, H., Metabolic Maps of Pesticides: Ecotoxicology and Environmental Quality Series, Academic Press, New York, 1982
17. Aizawa, H., Metabolic Maps: Pesticides, Environmentally Relevant Molecules and Biologically Active Molecules , Academic Press, San Diego, 2001
18. Aizawa, H., Metabolic Maps: Pesticides, Environmentally Relevant Molecules and Biologically Active Molecules , Academic Press, San Diego, 2001; Hultgren, R. P., Hudson, R.

J., Sims, G. K., *J. Agric. Food Chem.*, v.50, N 11 (2002) Page:3236; Menniti, C., Cambon, J. P., Bastide, J., *Agric. Food Chem.*, v.51, N 12, (2003) Page:3525

19. Aizawa, H., *Metabolic Maps: Pesticides, Environmentally Relevant Molecules and Biologically Active Molecules*, Academic Press, San Diego, 2001; *Pesticides: Benefaction or Pandora's Box? A synopsis of the environmental aspects of 243 pesticides*, J. B. H. J. Linders, J. W. Jansma, B. J. W. G. Mensink, K. Otermann, Report no 679101014, march 1994.

20. Aizawa, H., *Metabolic Maps: Pesticides, Environmentally Relevant Molecules and Biologically Active Molecules*, Academic Press, San Diego, 2001; Ganapathy, C., *Environmental Fate of Hexazinone*, May 1, 1996, pp. 1-15;

<http://www.cdpr.ca.gov/docs/empm/pubs/fatememo/hxzinone.pdf>

21. Chow, K.T., Pope, M.K., Davies, J., *Microbiology*, v. 145 (1999)

22. Streck, H.J., DuPont Agricultural Products, Chlorsulfuron,

23. Shimoni, E., Baasov, T., Ravid, U., Shoham, Y., *J. Biol. Chem.*, v. 277, N 14, (2002)

24. EPA: Federal Register Environmental Documents: Clethodim; Pesticide Tolerance, v.66, N108 (2001)

25. Tetradifon; *Environmental Health Criteria* 67, 1986

(<http://www.intox.org/databank/documents/chemical/tetradfn/ehc67.htm>)

26. *Pesticide Residues Series, N 1: Chlordimeform*, World Health Organization, Geneva, 1972;

<http://www.inchem.org/documents/jmpr/jmpmono/v071pr02.htm>

27. Potrawfke, Th., Timmis, K. N., Wittich, R. M., *Applied and Environmental Microbiology*, v. 64, N 10, (1998); *The University of Minnesota Biocatalysis/Biodegradation Database*;

http://umbbd.ahc.umn.edu/tcb/tcb_map.html

28. Thiometon (*Pesticide residues in food: 1976 evaluations*);

<http://www.inchem.org/documents/jmpr/jmpmono/v076pr24.htm>

29. Bentazone; Environmental Project N 902, 2004
http://www.mst.dk/udgiv/publications/2004/87-7614-185-3/html/helepubl_eng.htm; Huber, R., Otto S., Rev. Environ. Contam. Toxicol., vol. 137, 1994,
30. Ethephon (Pesticide residues in food: 1977 (evaluations);
<http://www.inchem.org/documents/jmpr/jmpmono/v077pr25.htm>
31. European Commission, Health & Consumer Protection Directorate- General, 13 February 2004; Hsu, J.C., Camper, N.D., Can. J. Microbiol., v. 21, N 12, 1975
32. European Commission, Health & Consumer Protection Directorate- General, 13 February 2004
33. Trifluralin, OSPAR Commission, 2005;
http://www.ospar.org/documents/dbase/publications/p00203_BD%20on%20trifluralin.pdf.
34. Yoder, R. N., Huskin, M. A., Kennard, L. M., Zabik, J. M., Agric. Food Chem., v. 48, No 9, 2000,
35. Finkelstein, Z. I., Baskunov, B.P., Rietjens, I.M., Boersma, M. G., Vervoort, J., Golovleva, L. A., Journal of Environmental Science and Health, Part B, v. 36, N 5 , 2001
36. Tebuconazole (188);
http://www.fao.org/ag/AGP/AGPP/Pesticid/JMPR/Download/94_eva/tebucona.pdf
37. Shen, Y., Stehmeier, L. G., Voordouw, G., Appl. Environ. Microbiol., v. 64, N 2, (1998)
38. Myclobutanil; Decision Document E93-01, Agriculture Canada, Food Production and Inspection Branch, June 15, 1993
39. Sodium acifluorfen (62476-59-9) Adverse Effects
<http://www.fluoridealert.org/pesticides/epage.acifluorfen.na.effect.htm>; United States Environmental Protection Agency; Office of Prevention, Pesticides, and Toxic Substances; Washington, D.C. 20460, April 27, 2001; Sodium acifluorfen, PC Code 114402
40. Bhadbhade, B. J., Sarnaik, S. S., Kanekar, P. P., Journal of Applied Microbiology, v.93, N 2, (2002)

41. Fenpropimorph (188); Explanation

(http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGP/AGPP/Pesticid/JMPR/Download/95_eva/fenpro.pdf)

42. Methomyl (EHC 178, 1996); International Programme on Chemical Safety; Environmental Health Criteria 178 (<http://www.inchem.org/documents/ehc/ehc/ehc178.htm>); Du Pont Lannate Insecticide - Technical Bulletin; Methomyl (American Standard K 62.70-1967)

43. Carbendazim (EHC 149, 1993); International Programme on Chemical Safety; Environmental Health Criteria 149 (<http://www.inchem.org/documents/ehc/ehc/ehc149.htm>)

44. Public Release Summary on Evaluation of the New Active SPINOSAD in the Products; National Registration Authority for Agricultural and Veterinary Chemicals, October 1998, Canberra, Australia

45. Pesticides: Benefaction or Pandora 's Box? A synopsis of the environmental aspects of 243 pesticides, J. B. H. J. Linders, J. W. Jansma, B. J. W. G. Mensink, K. Otermann, Report no 679101014, March 1994.

46. Public Release Summary on Evaluation of the New Active Carfentrazone - ethyl in the Products; Affinity 400 DF Herbicide; National Registration Authority for Agricultural and Veterinary Chemicals, April 2000, Canberra, Australia; NRA Ref.51555.

47. Target Herbicide, Material Safety Data Sheet Syngenta Crop Protection Canada, Inc., 140 Research Lane, Research Park, Guelph, ON, N1G 4Z3

48. Tingle, C. C. D., Rother, J. A., Dewhurst, C. F., Lauer, S., King, W. J., Pesticide Action Network UK, November, 2000, Health and environmental effects of fipronil; Fipronil (202) (http://www.fao.org/ag/AGP/AGPP/Pesticid/JMPR/Download/2001_eva/08%20Fipronil.pdf); Connelly, P., Environmental Fate of Fipronil, December 2001, pp. 1 - 17 (<http://www.pw.ucr.edu/textfiles/fipronil.pdf>)

49. Dejonghe, W., Berteloot, E., Goris, J., Boon, N., Crul, K., Maertens, S., Hofte, M., De Vos, P., Verstraete, W., Top, E.M., Applied and Environmental Microbiology, v. 69, N 3, 2003,

50. Scribner, E. A., Thurman, E. M., Zimmerman, L. R., U. S. Geological Survey (USGS) Laboratory in Lawrence, Kansas, Analysis of Selected Herbicide, Metabolites in Surface and Ground Water of the United States.
51. Thiocarbamate pesticides: a general introduction (EHC 76, 1988)
(<http://www.intox.org/databank/documents/chemical/thiocarb/ehc76.htm>)
52. Azoles and Analogues, Bitertanol; PSD (1994) Pesticide Safety Directorate (UK MAFF), Evaluation N 92
53. Sims, J.L., Suflita, J.M., Russell, H. H., United States Environmental Protection Agency; EPA Ground Water Issue (EPA/540/4-90/054), January, 1991
54. Hay, A. G., Focht, D. D., Applied and Environmental Microbiology, v. 64, N 6, (1998),
55. Roy, S., Kumar, R., Roy, S., Sharma, C. B., Biomed Chromatogr.,v. 10, N2, (1996), ;
Hayatsu, M., Hirano, M., Tokuda, S., Applied and Environmental Microbiology, v. 66, N 4, (2000), ; Kanaly, R. A., Kim, I. S., Hur, H. G., J. Agric. Food Chem., v. 53, N 16, (2005), ;
Chemical Fact Sheet; Fenitrothion (<http://www.speclab.com/compound/c122145.htm>);
Matsushita, T., Matsui, Y., Taniwaki, Sh., Inoue, T., Chemosphere, vol. 47, 2002,
56. Elsgaard, L., Pojana, G., Miraval, T., Eriksen, J., Marcomini, A., Chemosphere, vol. 50, (2003); Eichhorn, P., Lopez, O., Barcelo, D., J. Chromatogr. A., v. 1067, N 1-2, (2005)
57. Oremland, R. S., Miller, L. G., Culbertson, Ch. W., Connell, T. L., Jahnke, L., Applied and Environmental Microbiology, v. 60, N 10, (1994); Miller, L. G., Connell, T. L., Guidetti, J. R., Oremland, R. S., Applied and Environmental Microbiology, v. 63, N 11, (1997)
58. Steffan, R. J., McClay, K., Vainberg, S., Condee, Ch. W., Zhang, D., Applied and Environmental Microbiology, v. 63, N 11, (1997); Kharoune, M., Kharoune, L., Lebault, J. M., Paus, A., Environmental Toxicology and Chemistry, v.21, N 10, (2002); The University of Minnesota Biocatalysis/Biodegradation Database; http://umbbd.ahc.umn.edu/mtb/mtb_map.html
59. Radosevich, M., Traiana, S.J., Hao, Y.L., Tuovinen, O.H., Applied and Environmental Microbiology, v. 61, N 1, (1995); DeSouza, M.I., Sadowsky, M. J., Waskett, L. P., Journal of

Bacteriology, vol.178, N 16, (1996); Pesticides: Benefaction or Pandora 's Box? A synopsis of the environmental aspects of 243 pesticides, J. B. H. J. Linders, J. W. Jansma, B. J. W. G. Mensink, K. Otermann, Report no 679101014, March 1994.

60. Di Primo, P., Gamliel, A. , Austerweil, M., Peretz-Alon, I., Beniches, M., Steiner, B., Katan, J., Evidence for accelerated degradation of metham-sodium and dazomet in Israel, pp. 88-1 - 88-5 (<http://mbao.org/2001proc/088%20Gamliel%20A%20mbao01b.pdf>) ; El Hadiri, N., Ammati, M., Chgoura, M., Mounir, K., Chemosphere, vol. 52, N 5, (2003); Pesticides: Benefaction or Pandora's Box? A synopsis of the environmental aspects of 243 pesticides, J. B. H. J. Linders, J. W. Jansma, B. J. W. G. Mensink, K. Otermann, Report no 679101014, March 1994.; Wales, P. C., Evaluation of Methyl Isothiocyanate as a Toxic Air Contaminant, Part A - Environmental Fate, August 2002, pp. 1-127;

<http://www.cdpr.ca.gov/docs/emppm/pubs/mitc/augfinl02/augparta.pdf>

61. Pohlenz, H. D., Boidol, W., Schuttke, I., Streber, W. R., Journal of Bacteriology, vol. 174, N 20, (1992); Pesticides: Benefaction or Pandora 's Box? A synopsis of the environmental aspects of 243 pesticides, J. B. H. J. Linders, J. W. Jansma, B. J. W. G. Mensink, K. Otermann, Report no 679101014, March 1994.

62. Di Primo, P., Gamliel, A. , Austerweil, M., Peretz-Alon, I., Beniches, M., Steiner, B., Katan, J., Evidence for accelerated degradation of metham-sodium and dazomet in Israel, pp. 88-1 - 88-5 (<http://mbao.org/2001proc/088%20Gamliel%20A%20mbao01b.pdf>) ; Pesticides: Benefaction or Pandora 's Box? A synopsis of the environmental aspects of 243 pesticides, J. B. H. J. Linders, J. W. Jansma, B. J. W. G. Mensink, K. Otermann, Report no 679101014, March 1994.; Wales, P. C., Evaluation of Methyl Isothiocyanate as a Toxic Air Contaminant, Part A - Environmental Fate, August 2002, pp. 1-127;

<http://www.cdpr.ca.gov/docs/emppm/pubs/mitc/augfinl02/augparta.pdf>

63. Pesaro, M., Nicollier, G., Zeyer, J., Widmer, F., Appl. Environ. Microbiol., vol 70, N 5, (2004); Sukul, P., Spitteller, M., Rev. Environ. Contam. Toxicol., vol. 164, (2000); Pesticides:

Benefaction or Pandora 's Box? A synopsis of the environmental aspects of 243 pesticides, J. B. H. J. Linders, J. W. Jansma, B. J. W. G. Mensink, K. Otermann, Report no 679101014, March 1994.

64. Pesaro, M., Nicollier, G., Zeyer, J., Widmer, F., *Appl. Environ. Microbiol.*, vol 70, N 5, (2004)

65. Pesticides: Benefaction or Pandora 's Box? A synopsis of the environmental aspects of 243 pesticides, J. B. H. J. Linders, J. W. Jansma, B. J. W. G. Mensink, K. Otermann, Report no 679101014, March 1994.; Degradation of 2,6-Dichlorobenzonitrile (Dichlobenil) to BAM as Compared to the Degradation of Benzonitrile, Holtze, M. S., Sorensen, J., Hansen, H. C. B., Aamand, J.; 1st RECETO Symposium. 8 October 2003. Glostrup, Denmark. Abstract Volume. (<http://www.receto.dk/Education/Symposia/1st%20RECETO%20symposium.pdf#search='Dichlobenil%20RECETO%20Symposium'>)

66. International Programme on Chemical Safety; Environmental Health Criteria 184; Diflubenzuron (EHC 184, 1996). (<http://www.inchem.org/documents/ehc/ehc/ehc184.htm>); United States Environmental Protection Agency EPA 738-R-97-008, August 1997; Reregistration Eligibility Decision (RED); Diflubenzuron; Pesticides: Benefaction or Pandora 's Box? A synopsis of the environmental aspects of 243 pesticides, J. B. H. J. Linders, J. W. Jansma, B. J. W. G. Mensink, K. Otermann, Report no 679101014, March 1994.

67. Zablutowicz, R. M., Hoagland, R. E., Staddon, W. J., Locke, M. A., *J. Agric. Food Chem.*, v. 48, N 10 (2000); Pesticides: Benefaction or Pandora 's Box? A synopsis of the environmental aspects of 243 pesticides, J. B. H. J. Linders, J. W. Jansma, B. J. W. G. Mensink, K. Otermann, Report no 679101014, March 1994.

68. Arrault, S., Desaint, S., Catroux, C., Semon, E., Mouglin, C., Fournier, J. C., *Pest. Manag. Sci.*, v.58, N 12, (2002); Camper, N. D., Kim, J. H., Riley, M. B., *J. Environ. Sci. Health B.*, v.36, N 6, (2001); Pesticides: Benefaction or Pandora 's Box? A synopsis of the environmental aspects of 243 pesticides, J. B. H. J. Linders, J. W. Jansma, B. J. W. G. Mensink, K. Otermann,

Report no 679101014, March 1994.; Drakeford, C. E., Camper, N. D., Riley, M. B.,
Chemosphere, v.50, (2003),

69. United States Environmental Protection Agency, Washington, DC 20460; Memorandum:
Environmental Fate and Effects Division RED Chapter for Phosmet, April 24, 1998 ; Suter, H.
C., White, R. E., Heng, L. K., Douglas, L. A., Journal of Environmental Quality, vol. 31, (2002)

70. Dimethoate (27), Omethoate (55), Formothion (42) Explanation
(http://www.fao.org/ag/AGP/AGPP/Pesticid/JMPR/Download/98_eva/dimetho.PDF); United
States Environmental Protection Agency; Memorandum, February 4, 1999
(<http://www.epa.gov/pesticides/op/dimethoate/efedrra.pdf>); Dimethoate; Pesticide Residues in
Food - 1984 Evaluations 1984
(<http://www.inchem.org/documents/jmpr/jmpmono/v84pr19.htm>); Pesticides: Benefaction or
Pandora 's Box? A synopsis of the environmental aspects of 243 pesticides, J. B. H. J. Linders, J.
W. Jansma, B. J. W. G. Mensink, K. Otermann, Report no 679101014, March 1994.

71. Kim, J., Liu, K. H., Kang, S. H., Koo, S. J., Kim, J. H., J., Agric. Food Chem., v.51, N 3,
(2003); Kim, J., Liu, K. H., Kang, S. H., Koo, S. J., Kim, J. H., Pest. Manag. Sci., vol. 59, N 9
(2003)

72. Radianingtyas, H., Robinson, G. K., Bull, A. T., Microbiology, vol. 149, (2003); Spectrum
Laboratories: Chemical Fact Sheet - Cas # 106478; 4-Chloroaniline
(<http://www.speclab.com/compound/c106478.htm>)

73. Ramanand, K., Sharmila, M., Sethunathan, N., Applied and Environmental Microbiology, v.
54, N 8, (1988); Evert, S., Environmental Monitoring Branch, Department of Pesticide
Regulation; Environmental Fate of Carbofuran
(<http://www.cdpr.ca.gov/docs/empm/pubs/fatememo/carbofuran.pdf>); Pesticides: Benefaction or
Pandora 's Box? A synopsis of the environmental aspects of 243 pesticides, J. B. H. J. Linders, J.
W. Jansma, B. J. W. G. Mensink, K. Otermann, Report no 679101014, March 1994.

74. Jacob, G. S., Schaefer, J., Stejskal, E. O., McKay, R. A., The Journal of Biological Chemistry, vol. 260, No 10, (1985) ; Gard, J. K., Fend, P. C., Hutton, W. C., Xenobiotica, vol. 27, No 7, (1997) ; Araujo, A. S., Monteiro, R. T., Abarkeli, R. B., Chemosphere, vol. 52, No 5, (2003) ; Pesticides: Benefaction or Pandora 's Box? A synopsis of the environmental aspects of 243 pesticides, J. B. H. J. Linders, J. W. Jansma, B. J. W. G. Mensink, K. Otermann, Report no 679101014, March 1994.; The University of Minnesota Biocatalysis/Biodegradation Database; http://umbbd.ahc.umn.edu/gly/gly_map.html

75. Zewell, T., Buffin, D., Health and Environmental Impacts of Glufosinate-amonium, May 2001, (Report); EFSA Scientific Report, 27, 14 March 2005, Conclusion on the peer review of glufosinate (<http://www.efsa.eu.int>); Pesticides: Benefaction or Pandora 's Box? A synopsis of the environmental aspects of 243 pesticides, J. B. H. J. Linders, J. W. Jansma, B. J. W. G. Mensink, K. Otermann, Report no 679101014, March 1994.

76. Haloxyfop (193), Identity;
http://www.fao.org/ag/AGP/AGPP/Pesticid/JMPR/Download/95_eva/haloxxy.pdf; Linlders, J. B. H. J., J. W. Jansma, B. J. W. G. Mensink, K. Otermann, Pesticides: Benefaction or Pandora 's Box? A synopsis of the environmental aspects of 243 pesticides, Report No 679101014, March 1994.

77. D'Ascenzo, G., A. Gentili, S. Marchese, A. Marino, D. Perret, Analusis, vol.26, 1998,; Linlders, J. B. H. J., J. W. Jansma, B. J. W. G. Mensink, K. Otermann, Pesticides: Benefaction or Pandora 's Box? A synopsis of the environmental aspects of 243 pesticides, Report No 679101014, March, 1994.

78. Safety Data Sheet, 21.10.2003;
<http://www.mauk.co.uk/bugwatch/pdfs/Falcon%20100EC.pdf#search='propaquizafop'>; Linlders, J. B. H. J., J. W. Jansma, B. J. W. G. Mensink, K. Otermann, Pesticides: Benefaction or Pandora 's Box? A synopsis of the environmental aspects of 243 pesticides, Report No 679101014, March, 1994.

79. Pyridate, Decision Document E91-01; Product Management Division, Canada, August 2, 1991; http://www.pmra-arla.gc.ca/english/pdf/rdd/rdd_e9101-e.pdf; Linlders, J. B. H. J., J. W. Jansma, B. J. W. G. Mensink, K. Otermann, Pesticides: Benefaction or Pandora 's Box? A synopsis of the environmental aspects of 243 pesticides, Report No 679101014, March, 1994.
80. Extoxnet Pip, Quizalofop-P-ethyl; Pestizide Information Profiles, June 1996; <http://extoxnet.orst.edu/pips/quizalofop.htm>; Nou, T., Development of an Analytical Method for the Analysis of Quizalofop-P-ethyl and its Metabolite Quizalofop acid in Soybean by HPLC, February 2002; <http://library.uws.edu.au/adt-NUWS/uploads/approved/adt-NUWS20030718.141425/public/01front.pdf>; Linlders, J. B. H. J., J. W. Jansma, B. J. W. G. Mensink, K. Otermann, Pesticides: Benefaction or Pandora 's Box? A synopsis of the environmental aspects of 243 pesticides, Report No 679101014, March, 1994.
81. Tu, M., C. Hurd, J. M. Randall, Weed Control Methods Handbook, The Nature Conservancy, April 2001, Sethoxydim, pp. 7j.1 - 7j.5; <http://tncweeds.ucdavis.edu/products/handbook/19.Sethoxydim.pdf>; Linlders, J. B. H. J., J. W. Jansma, B. J. W. G. Mensink, K. Otermann, Pesticides: Benefaction or Pandora 's Box? A synopsis of the environmental aspects of 243 pesticides, Report No 679101014, March, 1994.
82. United States Environmental Protection Agency. Memorandum, July 8, 2004; Fluazifop-P-butyl; <http://www.fluorideaction.org/pesticides/f-p-b.opp-2004-0347-0010.pdf>; Tu, M., C. Hurd, J. M. Randall, Weed Control Methods Handbook, The Nature Conservancy, April 2001, Fluazifop-P-butyl, pp. 7c.1 - 7c.6; <http://tncweeds.ucdavis.edu/products/handbook/12.Fluazifop.pdf>; Linlders, J. B. H. J., J. W. Jansma, B. J. W. G. Mensink, K. Otermann, Pesticides: Benefaction or Pandora 's Box? A synopsis of the environmental aspects of 243 pesticides, Report No 679101014, March, 1994.
83. Patterson, M., Acephate, Analysis of Risks to Endangered and Threatened Salmon and Steelhead, February 9, 2004; Methamidophos, Pesticide residues in food: 1976 evaluations;

<http://www.inchem.org/documents/jmpr/jmpmono/v076pr17.htm>; Downing, E., Environmental Fate of Acephate; <http://www.cdpr.ca.gov/docs/emppm/pubs/fatememo/acephate.pdf>

84. Thiodicarb (154), Explanation;

http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGP/AGPP/Pesticid/JMPR/Download/2001_eva/16%20Thiodicarb.pdf; Linlders, J. B. H. J., J. W. Jansma, B. J. W. G. Mensink, K. Otermann, Pesticides: Benefaction or Pandora 's Box? A synopsis of the environmental aspects of 243 pesticides, Report No 679101014, March, 1994.

85. Logan, Sh., Tolyfluanid (162), Explanation;

http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGP/AGPP/Pesticid/JMPR/Download/2002_eva/tolyfluanid.pdf; Linlders, J. B. H. J., J. W. Jansma, B. J. W. G. Mensink, K. Otermann, Pesticides: Benefaction or Pandora 's Box? A synopsis of the environmental aspects of 243 pesticides, Report No 679101014, March, 1994.

86. Ganapathy, C., Environmental Fate of Triclopyr, January 2, 1997, pp. 1-18;

<http://www.cdpr.ca.gov/docs/emppm/pubs/fatememo/triclopyr.pdf>; Triclopyr, Herbicide Information Profile, November, 1996, pp.1-14; <http://www.fs.fed.us/r6/nr/fid/pubsweb/tri.pdf>; Patterson, M., Triclopyr Butoxyethyl Ester, May 6, 2004, pp. 1-31; <http://www.epa.gov/oppfead1/endanger/effects/triclo-analysis.pdf>

87. Beeman, R. W., F. Matsumura, J. Agric. Food Chem., v. 29, No 1, 1981,; Brown, J., Public Health Goal for Chlordane in Drinking Water, December 1997, pp. 1-48;

http://www.oehha.ca.gov/water/phg/pdf/chlor_c.pdf; Chlordane (AGP:1970/M/12/1), 1970, Evaluations of some pesticide residues in food;

<http://www.inchem.org/documents/jmpr/jmpmono/v070pr03.htm>; Hornsby, A. G., R. D. Wauchope, A. E. Herner, Pesticide Properties in the Environment; Springer, New York, 1996,

88. Nitrofen, Pesticide residues in food, Evaluations 1983;

<http://www.inchem.org/documents/jmpr/jmpmono/v83pr32.htm>; Kale, S. P., N. B. K. Murthy, K. Raghu, Bull. Environ. Contam. Toxicol., v. 59, 1997,

89. Leland, J. E., Evaluating the Hazard of Land Applying Composed Diazinon Waste Using Earthworm Biomonitoring, July 14, 1998; <http://scholar.lib.vt.edu/theses/available/etd-110198-185033/unrestricted/thesisleland2.pdf>
90. Regulatory Note - REG2003-02, Picolinafen, February 17, 2003; <http://www.pmr-arla.gc.ca/english/pdf/reg/reg2003-02-e.pdf>
91. Zoxamide, Electis; F-2140-327-01, 2004; http://kemi.se/upload/4144/Remiss_Electis_Bil1_PM.pdf; Zoxamide, Regulatory Note REG2001-09, July 19, 2001; <http://www.pmr-arla.gc.ca/english/pdf/reg/reg2001-09-e.pdf>; Zoxamide, NYS DEC Letter - Registration of Gavel 75DF Agricultural Fungicide 9/03, September 12, 2003; http://pmep.cce.cornell.edu/profiles/fung-nemat/tcmtb-ziram/zoxamide_reg_903.html
92. Flumioxazin, Australian Pesticides and Veterinary Medicines Authority, December 2003, pp. 1-59; <http://www.apvma.gov.au/publications/prsflum.pdf>; Flumioxazin (103361-09-7). Profile from Hazardous Substances Data Bank; <http://www.fluoridealert.org/pesticides/flumioxazin.hsdb.htm>
93. Tebufenozide, Identity; http://www.fao.org/AG/agP/AGPP/Pesticid/JMPR/Download/96_eva/tebufen1.pdf#search='tebufenozide%20chemical%20name'; Public Release Summary - Tebufenozide, Mimic; <http://www.apvma.gov.au/publications/prssteb.shtml>
94. Reregistration Eligibility Decision, Tebuthiuron, List A, Case 0054, June 15, 1994; http://www.epa.gov/oppsrrd1/REDs/old_reds/tebuthiuron.pdf
95. Fenvalerate, Environmental Health Criteria 95, Geneva, 1990; <http://www.inchem.org/documents/ehc/ehc/ehc95.htm>; Fenvalerate, CASRN: 51630-58-1; <http://www.cepis.ops-oms.org/bvsapud/i/fulltext/fenvale/fenvale.htm>

96. Lactofen, Memorandum, July 14, 2000;

<http://www.epa.gov/pesticides/reregistration/lactofen/lactofen.dw.reassessment.pdf#search='lactofen%20soil%20degradation'>

97. Malathion, Reregistration Eligibility Document;

<http://www.epa.gov/oppsrrd1/op/malathion/efedrra/.pdf>; Malathion, CASRN: 121-75-5;

http://www.gulflink.osd.mil/pest_final/pest_final_refs/n74en583/malathion_hsdh.html; Data Requirements for Malathion;

http://www.epa.gov/pesticides/op/malathion/efed_appendx.pdf#search='malathion%20soil%20degradation'

98. Martin, M., G. Mengs, J. L. Allende, J. Fernandez, R. Alonso, and E. Ferrer, Applied and Environmental Microbiology, v.65, No 2, 1999, ; Propachlor: Chemical Fact Sheet;

<http://www.speclab.com/compound/c1918167.htm>

99. Reregistration Eligibility Decision, Norflurazon, List A, Case 0229;

<http://www.epa.gov/oppsrrd1/REDs/0229.pdf>