**APPENDIX 3-1: Environmental Transport and Fate Data Analysis for Diazinon**

# Introduction

**APPENDIX 3-1** summarizes environmental fate data for diazinon and diazoxon. Data summarized here include data submitted to the U.S. EPA and open literature data. Open literature data were included in this summary when it was determine the information would add to the overall understanding of the environmental fate of diazinon and diazoxon. ECOTOX studies classified as ECOTOX plus are examined as to whether they would be relevant and important in understanding the environmental fate of diazinon. **APPENDIX 3-2: Fate Open Literature Review** summarizes the listing of ECOTOX plus studies and provides details on whether the study was used in the risk characterization. If the study involved environmental fate properties or dissipation studies, the data are discussed in this appendix. If the study involved monitoring, it is discussed in **APPENDIX 1-10: Summary of Diazinon Monitoring Data**.

**Table B 3-1.1** summarizes the identity information and physical-chemical properties of diazinon and diazoxon. Diazinon has an acid dissociation constant (pKa) of 2.6, indicating that its form will not change significantly at environmentally relevant pH and exists as a cation below this pH. Diazinon is uncharged between pH 4 and 7.[[1]](#footnote-1) The vapor pressure, air-water partition coefficient (KAW), and Cwater+soil/Cair indicate that diazinon should be considered semi-volatile from dry non-sorbing surfaces, slightly volatile from water, and slightly volatile to non-volatile from moist soil (OPPTS[[2]](#footnote-2) Guideline 835.6100 classifications).  The log octanol-water partition coefficient (log Kow) is 3.8 at 25oC and the log octanol-air partition coefficient (log KOA) is 8.4 suggesting that diazinon is likely to bioconcentrate in terrestrial organisms, if it does not degrade and is not metabolized (Armitage and Gobas, 2007; Gobas *et al.*, 2003; USEPA, 2009a). The atmospheric half-life suggests that diazinon will not be long-lived in the atmosphere; although it was frequently observed in atmospheric monitoring and does volatilize, especially from wet surfaces. Because diazinon’s log KOW is greater than three, risk to terrestrial organisms due to consumption of residues in aquatic organisms due to bioconcentration may occur.[[3]](#footnote-3) Typically, risk to sediment-dwelling organisms is evaluated when the log KOW is greater than three as compounds with higher KOWs have greater propensity to concentrate in sediment (40 CFR Part 158.630 Terrestrial and Aquatic Nontarget Organism Data Requirements); additionally, diazinon is very toxic to aquatic invertebrates that may be found in sediment; consequently, a risk assessment on sediment-dwelling organisms is relevant to diazinon.

**Table B 3-1.1. Summary of physical-chemical properties of diazinon and diazoxon1**

| **Parameter** | **Value and Units** | | | **Source and/or Comment for Diazinon2** |
| --- | --- | --- | --- | --- |
| **Diazinon** | | **Diazoxon** |
| PC Code | 057801 | | 657802 | -- |
| CAS Number | 333-41-5 | | 962-58-3 | -- |
| Structure | Chemical structure for DIAZINON | | 2D chemical structure of 962-58-3 | -- |
| SMILES Code | C1=C(C)N=C(N=C1O[P](OCC)(OCC)=S)C(C)C | | C1=C(N=C(N=C1O[P](OCC)(=O)OCC)C(C)C)C | -- |
| Chemical Name | *O*,*O*-diethyl *O*-2-isopropyl-6-methylpyrimidin-4-yl phosphorothioate | | * Phosphoric acid, diethyl 6-methyl-2-(1-methylethyl)-4-pyrimidinyl ester | -- |
| Empirical Formula | C12H21N2O3PS | | C12H21N2O4P | -- |
| Molecular Weight | 304.35 g/mole | | 288.28 g/mole | -- |
| Water Solubility at 25oC (mg/L) | pH | Solubility | 245 (estimated), pH NR | MRID 42970808,  40226101. Solubility not pH dependent at pH 5, 7, and 9 |
| NR | 65.5 |
| 6.07 | 59.5 |
| Vapor Pressure at 25oC | 7.22×10-5 torr  6.6×10-5 torr | | 1.1×10-5 torr (estimated) | MRID 42970809, 40226101. Semivolatile from dry nonadsorbing surfaces. |
| Henry’s Law constant | 1.1×10-7 atm-m3/mol at 23oC  4.4×10-7 atm-m3/mol at 25oC (estimated) | | 1.89×10-10 (estimated) | Calculated from measured value reported as a unitless value of 4.6×10-6 (Fendinger*et al.*, 1989)  Calculated with 6.6×10-5 torr vapor pressure and 59.5 mg/L water solubility. |
| Log Dissociation Constant (pKa) | 2.6 Temperature NR | | -- | MRID 46523401. Neutral at environmental pH. |
| Octanol-water partition coefficient (Kow) at 25oC | 4898 (log KOW=3.69) at 24oC | | 117 (log KOW 2.07) | MRID 42970810 |
| 6393 (log KOW=3.8) at 25oC | | MRID 40226101 |
| Air-water partition coefficient (KAW) | 1.8×10-5 (log KAW = -4.7) | | ND | Slightly volatile from a water surface.3  Estimated from vapor pressure and water solubility at 25oC and pH 6.07. |
| Octanol-air partition coefficient (KOA) | 3.5×108 (log KOA = 8.5) | | ND | Estimated from KAW and KOW. May bioconcentrate in terrestrial food chains if degradation is low 2 (Gobas et al. 2003; USEPA,, 2009a) |
| Cwater+soil/Cair | 2.31×105 | | ND | Estimated using and average Kd value of 4.02 L/kg soil. Rapidly lost from moist soil.3 |

NR=Not reported; Not determined

1 Estimated values were calculated according to “*Guidance for Reporting on the Environmental Fate and Transport of the Stressors of Concern in Problem Formulations for Registration Review, Registration Review Risk Assessments, Listed Species Litigation Assessments, New Chemical Risk Assessments, and Other Relevant Risk Assessments*” (USEPA, 2010b) or using similar calculations and provided by TOXNET (USNLM, 2014) or EPISuite (USEPA, 2014).

2 Data for diazoxon were obtained from TOXNET (USNLM, 2014).

3 Classifications for volatility were taken for Guideline 835.6100 (USEPA, 2010a).

# Transformation Rates in Laboratory Studies

**Table B 3-1.2** summarizes abiotic and biotic transformation data. Study results indicate that diazinon is not persistent[[4]](#footnote-4) in soil, sediment, or water. The dominant degradation process depends on environmental conditions. For example, at low pH, hydrolysis may be the primary degradation process, while at higher pH, aerobic metabolism will be more important.

Hydrolysis of diazinon is pH dependent, with the most rapid hydrolysis at pH 4 and 5 where time to 50% decline (DT50) values were 1.93 and 12.4 days, respectively. The slowest hydrolysis rates occurred at pH 7 where DT50s ranged from 82.3 to 139 days. Hydrolysis DT50s at pH 9 ranged from 61.9 to 77.1 days. Diazinon was stable to aqueous photolysis and acceptable soil photolysis data are not available. Ukepor and Halsall (2012) analyzed aqueous photolysis of diazinon in MilliQ water buffered to pH 7 and 9, and with added nitrate(0.3 and 3.0 mM), carbonate (0.3 and 3.0 mM), and dissolved organic carbon (DOC, 0.7 and 7 mg/L) at concentrations expected to occur in the natural environment. They observed no significant photolysis in the MilliQ water without added constituents. Diazinon did undergo aqueous photolysis (half-life ranged from 7-25 hours) in the presence of nitrate, carbonate, and DOC. Ukepor and Halsall (2012) indicated that degradation is most likely attributable to light-induced release of aqueous hydroxyl radicals (●OH) through photo dissociation of NO3-. Ukepor and Halsall (2012) stated that solar UV radiation could result in “excited” DOC which releases reactive oxygen species such as ●OH which then react with diazinon. Finally, carbonate radicals (CO3●-) may also result from reaction between carbonate and ●OH, and these radicals could react with diazinon.

Measured aerobic soil DT50 values ranged from 4.36 to 56.6 days in five soils. There is some uncertainty in the measured DT50 in three of the soils where up to 30% of applied radioactivity is unaccounted for in the study. DT50 values measured assuming that the lost radioactivity is diazinon are 1.1 to 2 times the DT50 for diazinon alone. All of the DT50 for diazinon plus lost radioactivity are within the range of DT50 observed in other soils for diazinon alone where there is not a high portion of unidentified radioactivity. Therefore, the data from these three soils may be used to better understand the degradation of diazinon in soil and to calculate a model input. Aerobic aquatic metabolism DT50 ranged from 9.94 to 10.2 days in two water and sediment systems. Anaerobic aquatic metabolism was measured in one soil and the DT50 was 24.5 days. Bondarenko *et al.* (2004) measured half-lives in water collected from four locations in the Upper Newport Bay-San Diego Creek watershed. The measured half-lives range from 6.3 to 41 days and are within the range of those observed studies submitted to the U.S. EPA[[5]](#footnote-5).

EFED exposure models employ first-order decay coefficients corresponding to half-life inputs for representing pesticide transformation processes, even though pesticide transformations in laboratory soil and aquatic systems often do not follow first-order decline. For this reason, the North American Free Trade Agreement (NAFTA) guidance was developed to generate a "representative half-life (tR)", for use as an exposure model input.[[6]](#footnote-6) These tR values for diazinon are shown in **Table B 3-1.2**. The representative half-life considers both initial and later (potentially slower) portions of the decline curve and is not necessarily numerically similar to the value of the DT50, rather it provides an input value for modeling that is generally expected to be conservative and is generated using a standardized procedure. The actual DT50 and DT90 from the representative degradation kinetic equations for the curve are used for descriptive purposes and for understanding the decline curve and the nature of the representative half-life used in modeling. Three out of eight of the decline curves characterizing parent alone were not the SFO (first-order) model. These decline curves had an initial rapid rate of decline followed by more gradual decline. The curves for which this occurred were described using the indeterminate-order rate equation (IORE). Actual DT50 and DT90 values for IORE are available in **Table B 3-1.2**. **Figure B 3-1.1** gives an example of a decline curve where the rate of decline changes over time. Half or the initial concentration declined over seven days and the next 50% decline occurred over 14 days (MRID 46867004, aerobic soil degradation in a Swiss soil). While degradation slowed during these studies, it did not apparently cease. For some curves in which the residues included both parent diazinon and an unidentified residue, the observed decline did stop (see example in **Figure B 3-1.1**).

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**Figure B 3-1.1. Example of decline curves for aerobic soil metabolism (MRID 46867004 and 46386605) for diazinon alone and diazinon plus lost radioactivity.**

**Table B 3-1.2. Abiotic and biotic transformation kinetics of diazinon and diazinon plus unidentified residue**

| **Study** | **System Details**  **(Kinetic Equation)** | **Kinetic Equation Fitted1 Value1** | | **Representative Half-life to Derive Model Input (days)2** | **Reference Or (MRID),**  **Study Classification**  **And Comments** |
| --- | --- | --- | --- | --- | --- |
| **DT50 (days)** | **DT90 (days)** |
| Hydrolysis | pH 4, 25oC, SFO | 1.93 | 6.42 | NA | MRID 48417201, acceptable. |
| pH 7, 25oC, SFO | 82.3 | 273 |
| pH 9, 25oC, SFO | 61.9 | 206 |
| pH 5, 23-25oC, SFO | 12.4 | 41.3 | 139  317\* | MRID 40931101, Acceptable. DT50 were calculated for parent only and parent plus an unidentified residue (shown with an asterisk) that increased throughout the study. |
| pH 7, 23-25oC, SFO | 139  317\* | 461  1053\* |
| pH 9, 23-25oC, SFO | 77.1  115\* | 256  384\* |
| Atmospheric Degradation | Hydroxyl Radical | 0.111 (est) | -- | NA | Estimated using EPIWEB v.4.1 for 12-hour day, 1.5x106 OH- molecules/cm3.  Diazinon is not expected to undergo long range transport in the vapor phase.2 |
| Air Photolysis | Photolysis at 40±5oC | >4.0 | Not reported | NA | MRID 49049901, supplemental due to no mass balance, large temperature range, and insufficient sampling. Diazoxon formed during heating of sample but not with exposure to light. |
| Hydroxyl Radical 30±5oC | 1.3 hours | Not reported | NA |
| Laboratory Volatilization | Dry soil, <5% MHWC  Wet soil, 60% WHD and 95% humidity | Dry: Flux 34.7 ng/cm2/hour  Wet: 347.7 ng/cm2/hour | | NA | MRID 48515501, supplemental. Applied in AG500 liquid formulation. 74% of diazinon as volatilized from a wet soil and 2.6% from a dry soil. |
| Aqueous Photolysis | pH 7, 25oC  Sterile  40oN sunlight  NO3-, CO32-, and DOC at 53oN, pH 7, 20oC3 | Stable  0.3-13 | | 0 | MRID 48417202, Acceptable.  (Ukpebor and Halsall, 2012) |
| Soil Photolysis | 25±5oC | No acceptable data | | NA | MRID 153229 and 153230, supplemental. Intensity of sunlight not reported. In one study, temperature was not reported. |
| Aerobic Soil Metabolism (20oC) | Swiss Silt Loam, 20oC  pH 7.7, 1.4% OC  (IORE) | 4.36 | 28 | 8.43 | MRID 46867004, supplemental. One replicate. |
| Sandy loam, 25oC  pH 7.8, 1.3%OC  (SFO) | 56.6 | 188 | 56.6 | MRID 44746001, supplemental. Unexplained loss of 25% of AR at all sampling intervals after 181 days. Value calculated for days 0-90 which had acceptable mass balance. |
| Sandy loam, 20oC  pH 6.4, 1.6%OC  (SFO, IORE\*) | 8.86  9.74\* | 29.4  80.8\* | 8.86  24.3\* | MRID 46386605, supplemental. Mass balances were incomplete with up to 30% loss of radioactivity in one soil. Degradation kinetics calculated for diazinon alone and diazinon plus lost radioactivity (designated with an \*). |
| Loamy sand, 20oC  pH 6.2, 0.8%OC  (IORE, IORE\*) | 18.2  37.7\* | 79.3  1285\* | 23.9  387\* |
| Clay loam, 20oC  pH 6.5, 2.8%OC  (SFO, IORE\*) | 9.7  10.8\* | 32.2  184\* | 9.7  55.5\* |
| Aerobic Aquatic | UK Pond, 25oC  pH 8.0, 4.0 %OC  (SFO) | 9.94 | 33.0 | 9.94 | MRID 46386604, acceptable. 23-49% unextracted residues which did not begin to increase until most diazinon degraded. Unextracted residues are unlikely to be parent. |
| UK lake, 20oC  pH 7.4, 1.20 %OC  (IORE) | 10.2 | 54.2 | 16.3 |
| San Diego Creek,21oC  PH 7.98 | 6.3 | Not Available | Not applicable | Bondarenko *et al*. (2004), qualitative. No mass balance conducted in water only. Provide a line of evidence in understanding persistence. |
| Peter’s Canyon Wash  pH 8.07 | 14.0 |
| San Joaquin Marsh  pH 8.86 | 6.4 |
| Upper Newport Bay  pH 8.02 | 41.0 |
| Anaerobic Aquatic | UK sandy loam soil, 20oC  pH 8.3, 2.6% OC  (SFO) | 24.5 | 81.3 | 24.5 | MRID 46386602, acceptable. Single samples |

OC=organic carbon; DTX=time for concentration/mass to decline by X percentage; SFO=single first order; DFOP=double first order in parallel; IORE=indeterminate order (IORE); SFO DT50=single first order half-life; TIORE=the half-life of a SFO model that passes through a hypothetical DT90 of the IORE fit; DFOP slow DT50=slow rate half-life of the DFOP fit, NA=not available, AR=applied radioactivity; est=estimated

\* Value calculated for parent and unidentified or lost radioactivity. These values are relevant in understanding the uncertainty in data.

1 DT50 and DT90 values were calculated using nonlinear regression and SFO, DFOP, or IORE equations. The equations can be found in the document, *Standard Operating Procedure for Using the NAFTA Guidance to Calculate Representative Half-life Values and Characterizing Pesticide Degradation* (USEPA, 2012c)*.*

2 The value used to estimate a model input value is the calculated SFO DT50, TIORE, or the DFOP slow DT50 from the DFOP equation. The model chosen is consistent with that recommended using the, *Guidance for Evaluating and Calculating Degradation Kinetics in Environmental Media (NAFTA, 2012)*. The same kinetic equation used to determine the representative model input value was used to describe the DT50 and DT90 results based on standard kinetic equations.

Transformation products resulting from environmental degradation of diazinon include:

* oxypyrimidine (2-isopropyl-4-methyl-6-hydroxypyrimidine, G-27550)
* diazoxon (diethyl 2-isopropyl-6-methyl-4-pyrimidinyl phosphate)
* GS-31144 (2-(2-Hydroxy-2-propanyl)-6-methyl-4(1H)-pyrimidinone)
* demethyl oxypyramidine (2-Ethyl-6-methyl-4(1H)-pyrimidinone), and
* desethyl diazinon.

Structures of the parent and degradates are shown in **Figure B 3-1.2**. Diazinon, diazoxon, and desethyl diazinon are organophosphates, with the sulfur atom replaced by oxygen in the case of the oxon. Oxypyrimidine and GS-31144 are not organophosphates, and are structurally similar to each other. The maximum amounts of degradates observed in fate studies are summarized in **Table** **B 3-1.3**. Oxypyrimidine, GS-31144, and desethyl diazinon were each found to be major degradates (*i.e*., present at greater than or equal to 10% of applied radioactivity) in at least one environmental fate study. All other degradates were minor. While desethyl diazinon was a major degradate in one hydrolysis study at one time point, it was not detected in any other study.

**Table** **B 3-1.3. Summary of maximum amount of transformation products observed in fate studies**

| **Compound** | **Maximum % of Applied Radioactivity Associated with Degradate (Time of Peak)**  **Amount Detected at Final Sampling Interval in Corresponding Study** | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Hydrolysis** | **Aqueous Photolysis** | **Soil Photolysis** | **Aerobic Soil** | **Aerobic Aquatic** | **Anaerobic Aquatic** | **Observed in Field Dissipation** |
| Oxypyrimidine, G-27550 | 98 (20d)a | 39 (360h)a | 24 (32.6h)a | 82 (21d)  1 (119d) | 70 (30d)  56 (100d) | 66 (87d)  56 (366d) | Yes |
| GS-31144 | NA | NA | 4 (32.6 h)a | 13 (195d)  6 (371d) | NA | 2 (59d)a | Yes |
| Diazoxon | ND | ND | ND | 0.6 (76d)a | NA | NA | ECM not reliable |
| Desethyl diazinon | 11 (30d)a | 4.3 (14d)a | NA | ND | NA | NA | NA |
| Demethyl diazinon | NA | NA | NA | NA | NA | NA | Yes |
| Demethyl oxypyrimidine | NA | NA | NA | NA | NA | NA | Yes |
| Unidentified | 7.2 (10d) | 0.9 (14d)a | 10 (32.6h)a | 6.2 (65d)  1.4 (119d) | 13 (30d)  10 (100d) | 4 (59d)a | NA |
| Unextracted | NA | NA | 34 (32.6h)a | 19.0 (65d)  15.9 (119d) | 49 (100d)a | 25 (59d)a | NA |
| CO2 | NA | NA | 2.3 (8d) | 85.6 (119d)ab | 5.3 (100d)a | 0.2 (59d)a | NA |

NA=notanalyzed; ND=not detected; d=day; h=hour; ECM=Environmental Chemistry Method

a Peak at final sampling interval in some studies.

b In some aerobic soil metabolism studies, significant CO2 formation occurred while in others minimal mineralization occurred (max CO2 in one soil was 6% of AR).

Oxypyrimidine was detected in every fate study submitted, and the maximum radioactivity observed associated with oxypyrimidine was frequently greater than 50% (maximum 82%). In the hydrolysis and photolysis studies, the maximum amount detected was observed at the final sampling interval indicating that oxypyrimidine’s abiotic degradation rates are slower than its rate of formation, and thus the maximum amount that may ultimately be formed was probably not observed. While residues declined with time in some of the aerobic metabolism studies, they often remained at very high percentages for significant periods of time. For example, in an aerobic aquatic metabolism study, 70% of applied radioactivity was associated with oxypyrimidine at 30 days, and 56% was still associated with oxypyrimidine at 100 days (MRID 46386604). The same trend was observed in the anaerobic aquatic study. This indicates that oxypyrimidine is relatively stable in both aerobic and anaerobic environments. GS-31144 was observed at a maximum of 13% of applied radioactivity at 195 days in one aerobic soil metabolism study, but was a minor degradate in all other studies. Demethyl oxypyrimidine was not monitored in laboratory studies but was observed at low concentrations (ranging from not detected to 0.17 mg/kg soil) near the level of detection in terrestrial field dissipation studies. Desethyl diazinon was only observed in hydrolysis studies, at a maximum of 11% of applied radioactivity[[7]](#footnote-7). In most samples, it was a minor residue.

Diazoxon is considered a residue of concern for both human health and ecological risk as it retains the organophosphorus functional group and has been shown to be more toxic to some organisms than the parent (USEPA, 2000, D270838, 2012b). Diazoxon was not monitored in many environmental fate studies, and was not detected in others in which it was monitored for, except for one aerobic soil metabolism study, in which it was observed at a maximum amount of 0.6% AR. Limits of quantitation for diazoxon were 0.01 to 0.02 mg/kg-soil in the studies in which it was looked for. Diazoxon was present in air before exposure to light in an air photolysis study (MRID 49049901) at 9.60 parts per billion. Diazinon was heated to cause volatilization and it was hypothesized by the study report author that diazoxon formed with the heating of diazinon and was not due to photolysis. Although formation and degradation of diazoxon cannot be quantified from available laboratory fate studies involving diazinon, diazoxon has been detected in air, rain, fog (Majewski and Capel, 1995) and surface waters in the United States (USGS, 2011). The predominant circumstances involving formation of diazoxon in the environment as well as its persistence are uncertain. This represents a major uncertainty in the Agency’s understanding of the fate and persistence of diazinon and its residues of concern.

|  |  |  |
| --- | --- | --- |
|  |  |  |
| |  |  | | --- | --- | | Diazinon | Diazoxon | | Desethyl Diazinon | Oxypyrimidine | | GS3114 | Demethyl Oxypyrimidine | |  |  |

**Figure B 3-1.2. Chemical structures of diazinon and its identified degradates**

# Sorption and Mobility

Using supplemental[[8]](#footnote-8) sorption coefficient estimates, diazinon is classified as moderately mobile to slightly mobile using the Food and Agriculture Organization (FAO) classification system, which means diazinon may be transported into surface and groundwater (FAO, 2000). Across studies, sorption coefficients correlated with the percent organic-carbon, and soil-water distribution coefficients normalized to organic-carbon ranged from 138 to 3,779 L/kg-organic carbon with an average value of 824 L/kg-organic carbon. The slope of a graph of the percent organic carbon by the Kd results in a slope of 3.64 and a KOC of 364 (R2=0.56). Results of several column leaching studies also demonstrate mobility of diazinon and oxypyrimidine, with both compounds found in column leachate (MRID 40512601, 132734, 118034). The majority of the radioactivity that leached through columns in these studies was associated with oxypyrimidine, however, a small percentage (approximately 0-3%) was also associated with diazinon. Available studies are discussed below and data are summarized in **Table B 3-1.4**. As these results are all considered supplemental with various deficiencies, they will be used as a line of evidence in exploring the range of potential sorption coefficients for diazinon and the impact of that range on predicted exposure. KOCWIN version 2.0 estimates a KOC value of 3034 using the Molecular Connectivity Index (MCI) method and 2184 L/kg using the log KOW method.[[9]](#footnote-9) The KOCWIN program has been updated since it was reviewed by OPP for use with pesticides; however, the previous review (Eckel *et al.*, 2006) found that for chemical classes that were not an outlier, 89% of predicted KOCs were within a factor of ten of the experimental value.

**Table B 3-1.4. Summary of supplemental sorption coefficients reported in submitted and open literature studies1**

| **Soil Texture** | **pH** | **%OC** | **Kd**  **L/kg-soil** | **KOC**  **L/kg-OC** | **KF**  (L/kg-soil)-1/n | **KFOC**  (L/kg-OC)-1/n | **Freundlich Exponent** | **Source and Comment** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sand | 6.2 | 0.2 | 1.0 | 651 | 1.50 | 752 | 0.82 | MRID 49019101, supplemental. Solvent concentration exceeded 0.1% and sorption coefficients likely underestimate sorption. Measured at 25oC. |
| Loam | 6.4 | 0.6 | 3.94 | 657 | 4.13 | 688 | 0.77 |
| sandy loam | 7.9 | 0.8 | 3.13 | 391 | 3.29 | 411 | 0.85 |
| silty clay | 7.1 | 1.0 | 7.72 | 772 | 7.37 | 737 | 0.85 |
| San Diego Creek | 7.1 | 1.05 | 3.5 | 334 | Not reported | | | (Bondarenko and Gan, 2004) Equilibration time was 4-hours and values may be underestimated. |
| Bonita Creek | 7.8 | 0.72 | 1.0 | 138 |
| silty clay | 7.7 | 0.48 | 18.14 | 3779 | 20.04 | 4204 | 1.05 | (Arienzo *et al.*, 1994). Mass balance not completed. Shook intermittently for 24-hours. Degradation (especially at low pH) and loss to vessel walls may have occurred. Identity of radioactivity not confirmed and diazinon may have degraded in some systems. Data to confirm equilibrium was achieved was not available for review. |
| clayed | 7.8 | 0.64 | 4.64 | 725 | 4.83 | 755 | 1.02 |
| clayed | 7.6 | 0.90 | 5.56 | 618 | 7.15 | 793 | 1.13 |
| clayed | 7.7 | 0.33 | 4.45 | 1348 | 5.35 | 1614 | 1.06 |
| sandy clay loam | 7.8 | 1.26 | 4.90 | 389 | 6.25 | 498 | 1.13 |
| sandy clay loam | 7.9 | 0.32 | 1.66 | 519 | 1.58 | 494 | 0.97 |
| sandy clay loam | 7.9 | 0.27 | 0.84 | 311 | 0.7 | 256 | 0.92 |
| sandy clay loam | 7.7 | 0.54 | 2.57 | 476 | 2.74 | 507 | 1.03 |
| sandy clay | 7.4 | 0.33 | 1.75 | 530 | 1.46 | 441 | 0.92 |
| sandy clay loam | 4.6 | 0.09 | 2.57 | 2856 | 1.58 | 1812 | 0.8 |
| sandy loam | 5.8 | 0.76 | 3.41 | 449 | 4.14 | 548 | 1.1 |
| sandy loam | 4.6 | 0.13 | 3.16 | 2431 | 2.58 | 2017 | 0.91 |
| sandy loam | 7.9 | 0.42 | 1.54 | 367 | 1.79 | 428 | 1.07 |
| clayed | 7.4 | 1.17 | 3.58 | 306 | 4.2 | 359 | 1.08 |
| clayed | 7.4 | 1.51 | 4.49 | 297 | 5.11 | 338 | 1.06 |
| sandy clay loam | 7.9 | 1.10 | 4.25 | 386 | 6.57 | 598 | 1.26 |
| sandy clay loam | 7.2 | 0.88 | 4.19 | 476 | 5.15 | 583 | 1.11 |
| sandy clay loam | 7.9 | 0.30 | 2.52 | 840 | 2.45 | 810 | 0.99 |
| sandy | 5.2 | 0.40 | 2.00 | 500 | 1.75 | 436 | 0.94 |
| sandy loam | 7.5 | 0.45 | 1.36 | 302 | 0.93 | 208 | 0.85 |
| sandy loam | 4.7 | 5.93 | 19.72 | 333 | 22.73 | 383 | 1.07 |
| sandy loam | 5 | 5.17 | 18.48 | 357 | 25.73 | 497 | 1.18 |
| loamy sand | 5.3 | 3.46 | 12.64 | 365 | 19.76 | 571 | 1.27 |
| loamy sand | 5.1 | 2.71 | 6.88 | 254 | 9.42 | 348 | 1.17 |
| sandy loam | 5.6 | 2.00 | 8.90 | 445 | 9.83 | 492 | 1.05 |
| sandy loam (Spain) | 7.5 | 0.01 | NR | 3779 | 9.95 | 1292 | 0.91 | (IglesiasJimenez *et al.*, 1996). Identity of radioactivity not determined. Equilibrium may not have occurred. Control sample not utilized. |
| Clay (Hungary) | 6.1 | 0.68 | NR | NR | 10.19 | 1493 | 0.97 | (Nemeth-Konda *et al.*, 2002). No mass balance or control test system. |
| Average | | | 5.3 | 824 | 6.8 | 818 | 1.0 | -- |
| Standard Deviation | | | 5.1 | 966 | 6.6 | 777 | 0.13 | -- |
| Coefficient of Variation | | | 0.97 | 1.2 | 0.98 | 0.95 | 0.13 | -- |

1 Measured at 20oC, unless otherwise stated.

One supplemental batch equilibrium study is available for diazinon (MRID 49091901). In this study, the maximum amount of solvent in test systems was not clear in the study report and it is likely that at least some test systems had a higher-than-recommended solvent concentration. This would result in an underestimation of sorption coefficients. However, measured sorption coefficients are within the range available in other studies for diazinon. Measured Freundlich organic-carbon normalized solid-water distribution coefficients (KOC) range from 411 to 752 L/kg-organic-carbon-1/n and Freundlich exponents range from 0.77 to 0.85, indicating that sorption coefficients were not independent of the diazinon equilibrium concentrations in water and sorption isotherms were nonlinear.

Open literature studies suggest that KFOC values range from 208 to 4,204 L/kg-organic carbon measured in 27 soils (Arienzo *et al.*, 1994; IglesiasJimenez *et al.*, 1996; Nemeth-Konda *et al.*, 2002). These values are uncertain as the studies either did not identify radiolabeled compounds or did not include a material balance. EPIWEB version 4.1 (USEPA, 2014) predicts a Koc of 2,184 L/kg-organic carbon, which is within the range of the values reported in the open literature. These studies are discussed further below.

Nemeth-Konda *et al.* (2002) conducted batch equilibrium experiments where the sorption coefficient was based on the difference between the total diazinon applied and the total diazinon measured in solution after shaking for 24 hours at 20oC. The soil was a brown Hungarian forest soil with clay alluviation which contained 0.68% organic carbon and pH of 6.1. The soil was sieved (<2mm) and the solution was a 0.01 M calcium chloride solution. A control polypropylene tube showed loss of diazinon to walls and the diazinon experiment was conducted in glass tubes with Teflon lined lids. The measured organic carbon normalized Freundlich sorption coefficient was 1493 L/kg-organic carbon and the corresponding Freundlich exponent was 0.98. The main deficiency in this experiment is that there was no mass balance for the total system and loss of diazinon was observed in the polypropylene tubes. It was not clear from the study description whether there was a control tube for the experiment conducted with glass tubes. Additionally, the location that the soil was collected from was not described and it was not determined whether the collected soil already contained some background diazinon.

Iglesias-Jimenez *et al.* (1996) measured sorption coefficients of diazinon with and without the presence of surfactants on a soil collected in Salamanca, Spain. Batch equilibrium experiments were conducted with radiolabeled diazinon and the amount of radioactivity in the solution was measured. Sorption coefficients were calculated based on the difference between the total radioactivity added to the system and the amount measured in a 1 mL aliquot of solution. The batch equilibrium systems were shaken for 16 hours at 20oC and soils were sieved (<2mm). The experiments were conducted in duplicate. Typically, batch equilibrium experiments require that the identity of the radioactivity be confirmed to determine whether degradation occurred. Additionally, if a sorption coefficient is going to be determined based on the difference in the amount added and the amount added to solution, usually a control is completed to determine whether loss of the chemical occurred through either degradation or sorption to the vessel walls. Sorption of diazinon to vessel walls was observed by Nemeth-Konda *et al.* (2002) with polypropylene tubes and Iglesias-Jimenez et al. (1996) did not report the type of centrifuge tube used. The control sample serves to determine the total amount in the system. These two deficiencies indicate that these measured sorption coefficients may not be accurate. The measured Freundlich distribution coefficient in a Eutric Cambisol collected in Spain was 9.95 L/kg and the Freundlich coefficient was 0.91. The soil contained 0.01% organic carbon and the pH was 7.5. A KOC value was not reported but was estimated to be 1292 L/kg-organic carbon. This study did not determine whether diazinon was present in the soil before it was used in the sorption experiment.

Arienzo *et al.* (1994) measured sorption of diazinon in 25 soils at 20oC. Twenty soils were from Marismas del Guadalquivir and five soils were from the province of Salamanca. Soils were air dried and sieved (<2-mm). Batch equilibrium experiments were conducted with radiolabeled diazinon with initial concentrations ranging from 5-25 mg/L. The samples were shaken intermittently for 24 hours at 20oC. Preliminary experiments indicated that equilibration was achieved; however, data were not available to confirm this. After 24-hours the samples were centrifuged and a 1-mL aliquot was removed and the radioactivity measured in the aliquot. Sorption coefficients were calculated based on the difference between the diazinon added and the amount of radioactivity measured in the aliquot. The type of container that the samples were shaken in was not specified. It is possible that some sorption of diazinon to vessel walls occurred or degradation of diazinon occurred. Additionally, the identity of the compound that radioactivity was associated with was not determined. It is likely that some diazinon degraded during the study (especially at low pH), and the sorption coefficients may not be specific to diazinon. Organic-carbon Normalized Freundlich Sorption coefficients for the 25 soils ranged from 208 to 4204 L/kg-organic carbon (L/kgoc).

Bondarenko and Gan (2004) measured sorption coefficients after aging diazinon in sediment over 56 days. Diazinon was added at a rate of 10 mg/kg sediment (dry weight equivalent) to San Diego Creek or Bonita Creek sediment collected in Orange County California. The samples were covered with aluminum foil and maintained at a temperature of 21 ± 2°C. Triplicate samples were removed at 0, 1, 2, 6, 28 and 56 days post treatment. The samples were mixed with 20 mL of 0.01M CaCl2 and placed on a mechanical shaker for four hours. After centrifugation, diazinon was extracted and measured in the aqueous phase and sediment phase and sorption coefficients were calculated. The results of this study are uncertain because equilibrium may not have been achieved in four hours. Measured Kd values increased in residence time in both sediments. Kd values ranged from 3.5 L/kg with no aging to 24.6 L/kg after 28 days of aging in the San Diego creek sediment. Kd values ranged from 1.0 L/kg with no aging to 10.7 L/kg after 28 days of aging in the Bonita creek sediment.

One batch equilibrium study (MRID 46579601) was submitted examining sorption of diazoxon. Diazoxon degraded rapidly in the study, soils were subjected to gamma-irradiation to reduce abiotic degradation rates, and the equilibration time was only 2 hours. Measured sorption coefficients are not reliable. EPIweb version 4.1 estimated a KOC of 175 L/kg organic-carbon and is classified as moderately mobile[[10]](#footnote-10).

# Field Dissipation

## Terrestrial Field Dissipation

The terrestrial field dissipation of diazinon was studied at sixteen United States sites on various crops, and on bare ground plots and with granular, wettable powder, and emulsifiable concentrate formulations. These studies are summarized in **Table B 3-1.5.** Application rates in the studies ranged from 2.2 lbs a.i./A to 10 lbs a.i./A with single and multiple applications depending on the site. These application rates are on the high end of current labeled uses of diazinon. The dissipation half-lives for diazinon ranged from five to 20 days and did not show a trend with cropped versus bare plots or formulations. Diazinon accumulated in soils with repeated application at some sites, but not at others. The highest measured concentration of diazinon in soil was 6.36 mg/kg-soil, and the maximum depth to which the compound leached was 48 inches. In one study in which diazinon was detected at 48 inches, that was the deepest depth sampled. In another, there were deeper sampling depths. Oxypyrimidine was detected at the maximum depth sampled (48 inches) at one site, and was detected at a maximum concentration of 3.26 mg/kg-soil at another site. GS-31144 was detected at a maximum depth of 0.45 meters (18 inches) and a maximum concentration of 0.178 mg/kg-soil at the same site. Diazoxon was detected near the level of quantitation (0.014 to 0.02 mg/kg-soil), and at a maximum depth of 12 inches. It is likely that these concentrations underestimate the true concentration of diazoxon, as this degradate was shown to be unstable when storing samples for 30 days, and samples were stored for lengths of time that were unspecified in some cases, and greater than 190 days in others. Given that diazoxon is a residue of concern, this produces significant uncertainty in the understanding of the environmental fate of diazinon and its degradates. It is possible that diazoxon could move into surface water through runoff.

**Table B 3-1.5. Summary of supplemental terrestrial field dissipation studies submitted for diazinong**

| **MRID** | **Study Location, Crop, Form** | **Half-life (days)b** | **Max depth of leaching (inches unless otherwise listed)/**  **Max Concentration mg/kg-soil unless otherwise listedc** | | | | | **lbs a.i./A, # of apps, app interval** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Diazinon** | **Oxypyr.** | **GS-31144** | **Diazoxone** | **demethyl G27550** |
| 46867006 | CA, turf, EC | d | 44.74 mg/kg dislodgeablef  138.34 mg/kg ww thatchf | NR | NR | 0.24 mg/kg ww dislodgeablef  0.64 mg/kg ww thatchf | NR | 5.0, 3x, 14 day |
| 46867006 | CA, bare, EC | d | 0-1 cma/29.23f | NR | NR | ND/ <0.01f | NR | 5.0, 3x, 14 day |
| 41320101 | CA, corn, G | 9 | 6/3.4 | 12/0.72 | 6/0.04 | ND | ND | 2.2, 4x, 7 day |
| 41320102 | CA, bare, G | 7 | 6/5.6 | 24/0.28 | 6/0.027 | ND | ND | 8, 1x |
| 41320103 | FL, citrus, WP | 5.51 | 24/1.022 | 48a/0.502 | 6/0.048 | **12/0.015** | 6/0.01 | 3.3-5.5, 5x, 7 day |
| 41320104 | CA, bare, EC | 20 | 48a/3.89 | 36/1.47 | ND | ND | ND | 8, 1x |
| 41320105 | CA, orange, EC | 7 | 36/2.82 | 48/1.45 | 12/0.04 | ND | 6/0.04 | 3.3-5.5, 5x, 7 day |
| 41432701 | IL, corn, G | 5 | 12/2.2 | 72/0.32 | 6/0.021 | ND | ND | 2.2, 7x, 7 day |
| 41432702 | IL, bare, G | 6 | 12/2.6 | 72/0.26 | <0.012 | ND | 6/0.012 | 8, 1x |
| 41432703 | CA, apples, WP | 10 | 18/1.538 | 48/1.267 | **18/0.178** | 6/0.02 | 6/0.011 | 3.3, 7x, 14 day |
| 41432704 | CA, bare, WP | 6 | **48**/2.313 | 48/2.029 | 6/0.128 | 6/0.012 | ND | 10, 1x |
| 41432705 | FL, bare, WP | 8.23 | 18/1.334 | **48a**/0.210 | ND | 12/0.014 | 6/0.015 | 10, 1x |
| 41432706 | NY, bare, EC | 5.3 | 12/**6.36** | 24/**3.26** | 12/0.13 | ND | **6/0.17** | 10, 1x |
| 41432707 | NY, apples, EC | 17 | 12/1.93 | 12/ 0.79 | 12/ 0.09 | ND | ND | 3.3, 7x, 14-21 day |
| 118024 | CA, turf, EC | <7 | 15/4.7 | NR | NR | NR | NR | 6, 1x |
| 118024 | WA, turf, EC | <7 | 15/3.4 | NR | NR | NR | NR | 5.5, 1x |
| 118024 | PA, turf, EC | <7 | 15/0.75 | NR | NR | NR | NR | 6, 1x |
| 118024 | TX, turf, EC | <7 | 15/0.30 | NR | NR | NR | NR | 4 1, 1x |

Form=formulation; G=granular; WP=wettable powder; EC=emulsifiable concentration; NR=not reported; Oyxpyr.=oxypyramidine; ww =wet weight

a Detected at the highest depth sampled.

b Half-life calculated using ln/linear regression and the single first order equation. The value reflects residues in the top six inches of soil only.

c Bold values indicate the greatest depth sampled or concentration detected in soil.

d Values could not be calculated due to insufficient analytical methods.

e Storage stability studies indicate that diazoxon was not stable in samples and these concentrations likely lower than actual concentrations that occurred in the field.

f Residues may be lower than actual values due to little information on analytical method. Dislodgeable diazinon residues were removed from turf with a mixture of water and an unspecified surfactant.

g All studies were classified as supplemental due to insufficient storage stability and analytical method data discussed in previous footnotes.

## Cranberry Bogs and Adjacent Reservoir

Szeto *et al.* (1990) evaluated concentrations of diazinon and diazoxon in cranberry bogs and adjacent waters after application of Diazinon 5G (a granular formulation)[[11]](#footnote-11). Diazinon was applied at a rate of 6 kg a.i./ha (5.35 lbs a.i./A)[[12]](#footnote-12) by aircraft to 19 hectares of cranberries in nine beds on July 26 and August 8. Cranberries bogs were surrounded by irrigation ditches, reservoirs, and waterways linking to two small tributaries to the Fraser River (near Forth Langley, British Columbia). Cranberry bogs were irrigated in April and water held with gates until after harvest. Sediment and water was collected at six stations within plots and outside of plots. Stations were as follows:

* one in an irrigation ditch in treatment plot,
* one in the reservoir adjacent to treatment plot,
* two in waterways outside of the dyke, and
* one at each of the two tributaries approximately 100 m downstream from the edge of the treatment plot.

Samples were collected at 10 days before the first application, pre-spray, post-spray, and at intervals up to 137 days after application. Recoveries of diazinon and diazoxon from water were near 100% but recoveries from sediment (69 to 76%) were low, likely due to hydrolysis (sediment pH ranged from 4.4 to 6.0). The limit of detection was 0.1 µg/L for sediment and 10 µg/kg for sediment. Results for the waterways and tributaries were similar and the results were averaged in the report (Table B 2). Diazoxon was not detected in any of the samples of water or sediment. The maximum diazinon concentration in water detected was 456 µg/L in irrigation ditches which decreased to below 100 µg/L within three to four days after treatment. Concentrations in the adjacent reservoir were lower with a maximum of 78.5 µg/L. Szeto *et al.* (1990) indicated residues observed in tributaries were much lower and were likely caused by leakage from the irrigation water through the gate between the reservoir and the waterways. Increased concentrations were also observed with a high rainfall event. Diazinon was also detected in sediment. Hydrolysis was likely a major loss mechanism. The pH of water ranged from 5.1 to 6.6 and diazinon is known to undergo hydrolysis in acidic environments and pH of sediment ranged from 4.4 to 6.0. This study was obtained from the open literature and the results are considered supplemental. **Table B 3-1.6** summarizes the concentrations of diazinon in water and sediment of cranberry bogs and adjacent waterways.

**Table B 3-1.6. Concentrations of diazinon in water and sediment of cranberry bogs and adjacent waterways**

| Site | Max diazinon concentration in water (days after first app) in µg/L | | | Max diazinon concentration in µg/kg-sediment (days after first app) | | |
| --- | --- | --- | --- | --- | --- | --- |
| After 1st App | After 2nd App | Final Detection | After 1st App | After 2nd App | Final Detection |
| Irrigation ditch | 338 (1d) | 456 (14d) | 0.2 (35 d) | 21200 (4d) | 8920 (21d) | 20 (137d) |
| Reservoir | 78.5 (2d) | 58.1 (17d) | 0.3 (51d) | 2380 (1d) | 110 (17d) | 10 (51d) |
| Waterways outside dyke | 29.1 (2d) | 2.6 (15d) | 0.1 (42d) | 80 (1d) | 20 (14d) | 10 (35d) |
| Tributaries 100 m downstream | 2.8 (4d) | 1.1 (15d) | 0.1 (35d) | 10 (4d) | Not detected | Not detected |

App= application

## Orchard Treatments and Pond Concentrations

Three field dissipation studies (MRID 41490401, 41490402, and 41490403) were conducted in which diazinon was applied to apple orchards in Adams County, Pennsylvania six times at 3 lbs a.i./A[[13]](#footnote-13) and concentrations of diazinon were measured in an adjacent pond[[14]](#footnote-14). The final applications took place in July. The maximum and range of detected concentrations in surface water are summarized in **Table B 3-1.7**. Samples were collected immediately after the first applications and at irregular intervals over the study period (*e.g.*, sampling intervals ranged from daily to weekly). Diazinon was detected shortly after the applications and rainfall events with concentrations decreasing through October, when the final samples were collected. The final mean measured concentrations[[15]](#footnote-15) ranged from 0.2 to 0.5 µg/L. The Jack Ely and Ronald Rice sites are similar to the aquatic bin 7 (high volume static bin). The R.R. Showers site is between aquatic bin 6 (moderate volume static bin) and 7.

**Table B 3-1.7. Summary of diazinon concentrations in ponds near apple orchards after applications of diazinon.\***

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Site/MRID | Maximum Diazinon Concentration (µg/L) | Range of Average Concentrations+  µg/L | Area of Watershed  Pond Volume, Surface area | Comments |
| Jack Ely/ MRID 41490402 | 82.1 | 0.5 to 44.1 | 10.2 acres watershed  10.2 acres treated  1.7 acre pond, 8.3 acre-feet | Detectable residues in pond sediment |
| R.R.Showers/ MRID 41490403 | 12.8 | 0.5 to 9.2 | 69.4 acre watershed  24.2 acres treated  4.9 acre pond, 21.5 acre-feet |  |
| Ronald Rice /MRID 41490401 | 113.0 | 0.6 to 53.4 | 33.7 acres watershed  14.1 acres treated  0.7 acre pond, 3.2 acre-feet | Stream in same watershed as the pond. Residues not quantifiable in pond sediment due to unacceptable recoveries in fortified samples. |

\*These studies were classified as supplemental.

+ Average of individual samples collected from three different zones of the pond on the same day.

# Bioconcentration Factor

## Characterization of available data

Available octanol-water partition coefficients for diazinon (Log Kow 3.69-3.81; USNLM 2009, MRID 42970810 and MRID 40226101) suggest that diazinon may bioaccumulate in aquatic organisms (due to uptake through respiration). Empirical bioconcentration factors (BCF) for diazinon range from 3-82 µg/kg-ww per µg/L in aquatic invertebrates (**Table B 3-1.8**) and 18-213 µg/kg-ww per µg/L in fish (**Table B 3-1.9**). These tables present whole-organism BCFs based on exposures that were ≥4 days in duration, which is representative of the time to steady-state in fish exposed to constant diazinon concentrations in water (estimated by KABAM).

**Table B 3-1.8. Diazinon BCFs for invertebrates**

| Test species (Scientific name) | BCF (µg/kg-ww per µg/L; whole organism; steady state) | Source |
| --- | --- | --- |
| Shrimp (*Panaeopsis joyneri*) | 3 | (Seguchi and Asaka, 1981) |
| Crayfish (*Procambarus clarkii*) | 5 | (Kanazawa, 1978) |
| Pond snail (*Cipangopoludina malleata*) | 6 | (Kanazawa, 1978) |
| Red snail (*Indoplanorbis exustus*) | 17 | (Kanazawa, 1978) |
| Amphipod (*Gammarus pulex)* | 13 | (Ashauer, Caravatti*, et al.*, 2010) |
| Daphnid (*Daphnia magna*) | 18 | (Kretschmann *et al.*, 2011) |
| American oyster (*Crassostrea virginica*) | 56 | (Williams, 1989) |
| Amphipod (*Gammarus pulex)* | 82 | (Ashauer, Hintermeister*, et al.*, 2010) |

**Table B 3-1.9. Diazinon BCFs for fish**

| Test species (Scientific name) | BCF (µg/kg-ww per µg/L; whole organism; steady state) | Source |
| --- | --- | --- |
| Guppy (*Labistes reticulatus*) | 18 | (Kanazawa, 1978) |
| Loach (*Misgurnus anguillicaudatus*) | 26 | (Seguchi and Asaka, 1981) |
| Killifish (*Oryzias latipes*) | 28 | (Tsuda *et al.*, 1995) |
| Silver crucian carp (*Cyprinus auratus*) | 37 | (Kanazawa, 1978) |
| Goldfish (*Cassius aurapus*) | 49 | (Tsuda *et al.*, 1997) |
| Rainbow trout (*Salmo gairdneri*) | 63 | (Seguchi and Asaka, 1981) |
| Motsugo (*Pseudorasbora parva*) | 64 | (Kanazawa, 1975) |
| Carp (*Cyprinus carpio*) | 65 | (Kanazawa, 1978) |
| Killifish (*Oryzias latipes*) | 94 | (Tsuda *et al.*, 1997) |
| Guppy (female) (*Lebistes reticulatus*) | 98 | (Tsuda *et al.*, 1997) |
| Carp (*Cyprinus carpio*) | 120 | (Seguchi and Asaka, 1981) |
| Guppy (male) (*Lebistes reticulatus*) | 142 | (Tsuda *et al.*, 1997) |
| Sheepshead minnow (*Cyprinodon variegatus*) | 147 | (Goodman *et al.*, 1979) |
| Topmouth gudgeon (*Pseudorasbora parva*) | 152 | (Kanazawa, 1978) |
| Sheepshead minnow (*Cyprinodon variegatus*) | 213 | (Goodman *et al.*, 1979) |

Available studies indicate that oxypyrimidine can make up a substantial portion of residues in tissue. Data from a registrant-submitted bioconcentration study in bluegill (MRIDs 40660808 and 41194401) indicate that diazinon is almost completely metabolized to oxypyrimidine, which is not of toxicological concern (available studies with fish indicate that it is practically non-toxic). In this study, oxypyrimidine accounted for 67-95% of total residues in fish, while diazinon only represented 2.3-10% of residues. Seguchi and Asaka 1981 exposed three different species of fish (carp, rainbow trout and loach) as well as shrimp to diazinon for 14 days. Quantification of residues in tissues indicated that the majority of residues (51-90%) were diazinon. Oxypyrimidine also made up a substantial proportion of the residues in the fish (9-28%) and shrimp (18-28%). Although both studies analyzed samples for diazoxon, no residues of this degradate of concern were detected.

The KABAM-estimated BCFs for invertebrates range 150-220 and for fish are 280. These estimates are based on mean Log Kow of 3.77 and the assumption that diazinon is not metabolized by fish. The estimated factors are expected to overstate the bioconcentration of diazinon because the chemical metabolizes substantially in aquatic organisms. Because a reliable metabolism rate constant cannot be generated for KABAM, the empirical BCF values for aquatic invertebrates and fish will be used to estimate diazinon concentrations in aquatic organisms.

## Description of excluded studies

Several studies related to bioaccumulation of diazinon in aquatic organisms were identified using ECOTOX (including the accepted and rejected bibliographies) but are not included in this analysis. The citations for these studies are listed below. Reasons for exclusion included the following:

1. Studies that reported BCFs or BAFs that were not whole organism (*e.g.*, tissues or organs);
2. BCFs or BAFs were from non-target monitoring studies;
3. studies that were based on total radioactive residues, and did not distinguish between diazinon and oxypyrimidine (these data do not represent bioconcentration of residues of concern);
4. BCFs or BAFs were based on measured concentrations not representative of steady state of diazinon (*i.e.*, values collected <4 days after initiation of exposure);
5. BCFs were published in another source.

Studies excluded from BCF analysis:

|  |
| --- |
| * Al-Attar, H. J. and Knowles, C. O. (1982). Diazinon Uptake, Metabolism, and Elimination by Nematodes. *Arch.Environ.Comtam.Toxicol.* 11: 669-673. |
| * Alam, M. K. and Maughan, O. E. (1992). The Effect of Malathion, Diazinon, and Various Concentrations of Zinc, Copper, Nickel, Lead, Iron, and Mercury on Fish. *Biol. Trace Elem. Res.* 34: 225-236. |
| * Ashauer, R.; Hintermeister, A.; O'Connor, I.; Elumelu, M.; Hollender, J., and Escher, B. I. Significance of Xenobiotic Metabolism for Bioaccumulation Kinetics of Organic Chemicals in Gammarus pulex. ACC. Eawag, Swiss Federal Institute of Aquatic Science and Technology , 8600 Dubendorf, Switzerland.//: AQUA; 2012; 46, (6): 3498-3508 (Author Communication Used) (Publ in Part as 153560). |
| * Azuma, T., Niiro, M., and Motobu, H. (1994). Removal of Pesticides from Wastewater at Golf Courses Using Plants (Removal by Mung Beans; Phaseolus radiatus L). *Bio-Med.Mater.Eng.* 4: 127-137. |
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| * Buisson, S., Bouchart, V., Guerlet, E., Malas, J. P., and Costil, K. (2008). Level of Contamination and Impact of Pesticides in Cupped Oyster, Crassostrea gigas, Reared in a Shellfish Production Area in Normandy (France). *J. Environ. Sci. Health Part B: Pestic. Food Contam. Agric. Wastes* 43: 655-664. |
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| * Fujikawa, M., Nakao, K., Shimizu, R., and Akamatsu, M. (2009). The Usefulness of an Artificial Membrane Accumulation Index for Estimation of the Bioconcentration Factor of Organophosphorus Pesticides. *Chemosphere [Chemosphere]. Vol. 74, no. 6, pp. 751-757. Feb 2009.* |
| * Kanazawa, J. (1981). Bioconcentration Potential of Pesticides by Aquatic Organisms. *Jpn.Pestic.Inf.* 39: 12-74. |
| * Kanazawa, J. (1981). Measurement of the Bioconcentration Factors of Pesticides by Freshwater Fish and Their Correlation with Physicochemical Properties or Acute Toxicities. *Pestic.Sci.* 12: 417-424. |
| * Kanazawa, J. (1983). A Method of Predicting the Bioconcentration Potential of Pesticides by Using Fish. *J.A.R.Q.(Jpn.Agric.Res.Q.)* 17: 173-179. |
| * Kanazawa, J. (1980). Prediction of Biological Concentration Potential of Pesticides in Aquatic Organisms. *Rev.Plant Prot.Res.* 13: 27-74. |
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| * Kuhr, R. J. and Tashiro, H. (1978). Distribution and Persistence of Chloropyrifos and Diazinon Applied to Turf. *Bull.Environ.Contam.Toxicol.* 20: 652-656 . |
| * Ludemann, D. and Neumann, H. (1961). Action of Modern Insecticides on the Organisms in Freshwater (Versuche uber die Acute Toxische Wirkung Neuzeitlicher Kontaktinsektizide auf Susswassertiere) . *Z.Angew.Zool.* 48: 87-96 (GER) (ENG ABS). |
| * Marganian, V. M. Jr. (1972). Dursban and Diazinon Residues in Biota Following Treatment of Intertidal Plots on Cape Cod - 1967-69. *Pestic.Monit.J.* 6: 160-165. |
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1. Estimated pKa values are reported in the open literature at 3.52 and 3.81 for the tertiary amine; however, submitted data did not support these pKa values. Diazinon reportedly can sorb via cation exchange and can form a six membered ring with metal cations (with the nitrogen, metal, and sulfur) (Bartlet-Hunt *et al.*, 2014; Smolen and Stone, 1997; Zhao *et al.*, 1999). [↑](#footnote-ref-1)
2. Office of Prevention, Pesticides, and Toxic Substances (OPPTS) is now the Office of Chemical Safety and Pollution Prevention (OCSPP); however, the guidelines still reference OPPTS and so the guidelines are referenced with OPPTS in this document. [↑](#footnote-ref-2)
3. The Kow (based) Aquatic BioAccumulation Model (KABAM) is the model used in EFED to assess potential risk to terrestrial organisms due to consumption or residues of pesticides in aquatic organisms. The user guide recommends that KABAM be used in the assessment when the log KOW value is between four and eight (USEPA, 2009b). A model is not currently available to assess risk to aquatic organisms due to bioconcentration and toxicity data because tissue residue analysis paired with toxicity are not available for aquatic organisms; however, bioconcentration factor data are typically requested for chemicals with a log KOW of at least three. [↑](#footnote-ref-3)
4. According to the Toxic Release Inventory Classification System, chemicals with half-lives greater than 60 days are classified as persistent and chemicals with half-lives greater than 180 days are classified as very persistent (USEPA, 2012a). [↑](#footnote-ref-4)
5. Mass balance data are not available for the Bondarenko *et al. (*2004) data these results are not used to develop a model input. [↑](#footnote-ref-5)
6. [<https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/nafta-guidance-evaluating-and-calculating>](http://www.epa.gov/oppefed1/ecorisk_ders/degradation_kinetics/NAFTA_Degradation_Kinetics.htm) [↑](#footnote-ref-6)
7. Desethyl diazinon was observed at pH 7 and 9 in MRID 48417201 and not analyzed at pH 4. [↑](#footnote-ref-7)
8. One submitted sorption study and several open literature studies report supplemental sorption coefficients. These sorption coefficients are uncertain due to different deficiencies in the study such as a solvent concentration that exceeded 0.1% by volume in some test systems, no mass balance, and not identifying radioactivity, to not determining whether equilibration occurred. [↑](#footnote-ref-8)
9. [↑](#footnote-ref-9)
10. Using the Food and Agriculture Organization (FAO) classification system (FAO, 2000). [↑](#footnote-ref-10)
11. There are currently no registered granular formulations in the United States. [↑](#footnote-ref-11)
12. The current registered application rate for use on cranberries is 3 lbs a.i/A with up to three applications. [↑](#footnote-ref-12)
13. The current registered use pattern on apples allows for application of diazinon at 2 lbs a.i./A with one application during the dormant season and one application during the foliar season. [↑](#footnote-ref-13)
14. The ponds were immediately adjacent to the orchards but were not surrounded by orchard. [↑](#footnote-ref-14)
15. Average of individual samples collected from three different zones of the pond on the same day [↑](#footnote-ref-15)