**Appendix 3-1: Environmental Transport and Fate Data Analysis for Malathion**

Non-targeted organisms may be exposed to malathion and its degradates through contamination of food, water, and air from off-target drift, volatilization, runoff, and direct application. Malathion exposure occurs readily through water given its solubility of 145 parts per million. It is semi-volatile), with a vapor pressure of 2.3\*10-5 torr (Fellers et al., 2004; LeNoir et al., 1999; McConnell et al., 1998; Sparling et al., 2001). The octanol-water partition coefficient ranging from 560 to 2000 and fish bioconcentration factors ranging from 4.2x to 18x are evidence that malathion does not biomagnify (MRIDs 40944103, 40966603, 43106401, 43106402, 43340301). Characterization of bioaccumulation is well documented in the assessment following bioaccumulation and long range transport Science Advisory Panel (EPA, 2010). Limited data are available on degradates and impurities, but the fate data provided to EFED for malathion and the more toxic degradate malaoxon was found to be acceptable for performing risk assessment (USEPA 2006). The primary route for malathion dissipation is metabolism to the less toxic malathion dicarboxylic and monocarboxylic acids. Malathion metabolizes readily in moist, microbially active soils. However, if malathion is in contact with metabolically inactive surfaces such as dry soils or impervious surfaces common in non-agricultural settings, photo-oxidation to the toxic degradate malaoxon can occur. Oxidation to malaoxon can also be catalyzed in the presence of chlorine. To a much more limited degree than chlorine or photo-oxidation, malathion can metabolize to malaoxon but is not a major degradate in that pathway. Malaoxon dissipates and degrades similarly to malathion, therefore, short duration malaoxon concentration peaks may be expected in non-agricultural streams during run-off events. Oxidation to malaoxon will increase toxicity. However, based on registrant submitted data and open literature reports, EFED concludes the primary routes of dissipation of malathion in surface soils appear to be microbially-mediated soil metabolism, with half-lives of <1 to 2.5 days, and to a lesser extent, pH-dependent hydrolysis. Hydrolysis in soil having pH 5, 7, and 9 results in half-lives of 107 days, 6.21 days, and 12 hours, respectively. Malathion monoester, ethyl hydrogen fumarate, diethyl thiosuccinate, malathion mono- and dicarboxylic acids, demethyl mono- and di-carboxylic acids, and CO2 are known degradates.

# TRANSFORMATION RATES IN LABORATORY STUDIES

## Hydrolysis and Photolysis

As stated above, hydrolysis rates of malathion vary dramatically with pH with half-lives ranging from 107 days in an acidic environment at pH 5 and 0.5 days in an alkaline environment at pH 9 (MRID 40941201). Malaoxon hydrolysis rates are more rapid, but also vary dramatically with pH. Malaoxon’s half life is 32 days at pH 5 and 0.16 days at pH 9 (MRID 46396601).

Though hydrolysis is the most dominant route of abiotic degradation, photolysis can also occur and can transform malathion to malaoxon. Malathion degrades to soil photolysis with a half-life of at least 173 days as dark controls indicate volatilization and soil degradation may have been occurring as well (MRID 41695501). Petreas *et al* (1992) addresses the dissipation of a malathion aerial spray and transformation products on teflon and filter paper and resulting volatilization. Dissipation was most likely to occur primarily through photolysis. Dissipation was most rapid on filter paper (DT50 = 39 hours) and longest on teflon (DT50 = 92 days) with malaoxon concentrations increasing over time on all surfaces. Nine days after application, malaoxon concentrations had increased to 10% to 20% of the concentration of original malathion deposition. Malaoxon air concentrations were at their maximum between 24 and 48 hours after application and malathion and malaoxon were still detectable in air at the end of the 10 day study.

## Aerobic soil metabolism:

Malathion metabolizes readily in moist, microbially active soils to malathion dicarboxylic and monocarboxylic acids. Aerobic soil metabolism of malathion is the only route of degradation that appears to result in a faster degradation rate than alkaline hydrolysis. In the aerobic soil metabolism registrant submitted studies, half-lives are biphasic with short initial half-lives of less than a day for the first ~48 hours; followed by longer half-lives of >10 days. In the first registrant submitted study, malathion initially degraded with a calculated half-life of ~0.2 days (based on the first 48 hours of study data) and subsequently degraded with a half-life of ~24 days (based on the study data from 48 hours to study termination at 92 days). This study was conducted using loam soil at a neutral pH of 6.1, incubated in the dark at 22 ± 2oC and hydrated to 75% of field capacity. A complementary experiment was conducted to determine the degradation rate of malathion in sterile soil. At 4 days post-treatment, malathion comprised close to 98% of the extractable radioactivity in sterile soil. The difference between half-lives of the sterile and non-sterile treatments indicates that microorganisms are important in the rapid degradation of malathion in soil under aerobic conditions. Numerous degradates or impurities were identified in the soil extracts and are identified as follows as a percent of applied radioactivity: dicarboxylic acid of malathion (18.7 - 36.7%), the β-monocarboxylic acid of malathion (2.8 - 7.3%), the α-monocarboxylic acid of malathion (1.9 - 2.5%), and malaoxon (0.6 - 1.8%). The presence of malaoxon at the beginning of this study and its decline over the study duration suggests that it occurs as an impurity rather than as a degradate (MRIDs 41721701 and 43166301). Malathion persistence under aerobic soil conditions has been examined in several open literature studies. Reported half-life values (from field and laboratory studies) vary from hours to 11 days. Persistence decreases with increasing microbial activity, moisture, and high pH. Though malaoxon does not readily form from malathion through aerobic soil metabolism, when malaoxon is formed, metabolism is an important route of dissipation. Aerobic soil metabolism rates for malaoxon on four soils(two sandy loams, a loamy sand, and a loam) are less than one day, similar to parent malathion (MRID 48903601).

## Aerobic Aquatic Metabolism

Estimated half-lives range from 0.3 day to 3.4 days across five water-sediment systems, one of which is from a registrant submitted study (MRID 42271601). Water phase pH ranged from 5.14 to 8.1 and, consistent with malathion’s hydrolysis behavior, most rapid degradation was observed in the test system with the most alkaline conditions. Major degradates in water and soil were similar: mono- and dicarboxylic acids of malathion, demethyl monoacid and demethyl diacid, while in sediment no demethyl diacid was detected. Malaoxon was analyzed in the registrant submitted study but was not detected. The EFED calculated half-life for malathion monocarboxylic acid was 3 days. Many open literature studies have been conducted on the fate and persistence of malathion in the aquatic environment. Reported degradation rates vary and are likely to be significantly increased by biological metabolism and pH. Eichelberger and Lichtenberg (1971) found 75% and 90% degradation in river water in one and two weeks, respectively. Guerrant *et al* (1970) found malathion half lives in pond, lake, river and other natural waters varied from 0.5 to 10 days and was dependent on pH. Other studies are summarized in Mulla *et al* (1981) and Howard (1991). NAWQA monitoring shows detections of malathion in large rural and urban streams. Aerobic aquatic metabolism rates and degradates of malaoxon are similar to malathion. Total system half-lives ranged from 0.8 to 6 days at water-phase pHs ranging from 5.3 to 8.4. Major degradates included α/β-monoacid malaoxon and monoethyl maleate (MRID 48508601). Bourquin (USEPA Gulfbreeze Laboratory, 1975) examined the microbial interaction with malathion in artificial saltmarsh ecosystems. Natural bacteria samples from uncontaminated marsh were added along with 10 ml of sea water and 10 gm of sediment to 250 ml flasks. 10 mg. aliquots of malathion in acetone were added every 7 days. Cultures were analyzed for malathion levels and compared to control vial residue levels. Increased salinity sped up the degradation process of the parent compound. However, malaoxon levels remained constant. Monocarboxylic acid and dicarboxylic acid levels increased. Conclusion was that chemical and microbiological processes will act to degrade the levels of parent malathion in saltmarsh environments.

## Anaerobic Aquatic Metabolism

In the registrant submitted anaerobic aquatic metabolism study, MRID 42216301, radiolabeled and technical grade malathion added to a sandy loam soil degraded with a half-life of approximately 2.5 days in sediment (pH 7.8) and water (pH 8.7). Hydrolysis was probably the main route of degradation since the pH was in the range which favors hydrolysis. Although most of the residues remained in the water phase (less than 20% of the applied radioactivity was associated with the sediment at any sampling interval), the degradation products were similar in both sediment and water phases. The degradation products at maximum concentrations in the water phase were the monocarboxylic acid of malathion (MCA, 28% at Day 4), dimethyl monocarboxylic acid (21% at Day 7), dicarboxylic acid (21 % at Day 14) and the dimethyl dicarboxylic acid metabolite (39% at Day 45). The degradation products at maximum concentrations in the sediment were the monocarboxylic acid of malathion (4.5% at 6 hours), demethyl monocarboxylic acid (8.1% at Day 45), and dicarboxylic acid (5.2% at Day 4). The EFED calculated half-life for malathion monocarboxylic acid was 11 days.

## Laboratory volatility

Three different malathion formulations [Ready To Use (RTU), Ultra Low Volume (ULV), and Emulsifiable Concentrate (EC)] added to a silt loam soil did not undergo any appreciable volatilization, when measured under different soil moisture regimes or air flow rates. No more than 5.1% of the applied radioactivity volatilized during the 16 days of the study (MRID 42015201).

# Leaching/adsorption/desorption

The FAO classifies malathion as moderately mobile. It is unlikely to reach ground water except in vulnerable soils with low organic-carbon content and/or the presence of shallow ground water. The short soil persistence of malathion, with metabolic half-lives less than one day, reduces the risk of leaching to ground water; however, it has been detected in ground water in three states (USEPA 1992). Based on batch equilibrium (adsorption/desorption) studies, unaged radiolabeled malathion was determined to be moderately mobile in sandy loam, sand, loam, and silt loam soils, with Freundlich Kads values of 0.83 - 2.47 L/kg and Koc values from 151-308 L/kg. Adsorption was correlated with organic carbon content. Values for 1/n for Kads were clustered in the range of 0.904 - 0.978 (MRID 41345201). Malaoxon was not detected in any leachate or soil extracts in concentrations ≥0.12% (≥6 μg/L) of applied radioactivity (MRID 43868601, 41345201, 43166301). Mobility of malaoxon is indistinguishable from malathion as Kads values range from 0.66 – 3.27 mL/g and Koc values range from 81 – 327 mL/g o.c. (MRID 48571804). Other degradates are significantly more mobile as malathion dicarboxylic acid Kads values range from 0.05 – 0.98 mL/g and Koc values range from 7 – 76 mL/g o.c. (MRID 48944501). Malathion monocarboxylic acid rapidly degrades in soil to malathion dicarboxylic acid and can be presumed to have similar mobility to its degradation product during its presence (MRID 48944502).

# Field Studies

## Terrestrial field dissipation

Data from open literature and registrant-submitted field dissipation studies indicate that malathion dissipates rapidly when applied in the field. In a registrant submitted field dissipation study using a rate of 1.16 lbs ai/A applied weekly, malathion or malaoxon residues were detected at ≤10 μg/kg in the 0-6" layer in cotton/bare ground sites in GA immediately after application and 1, 3, and 7 days after the last application. The application rates used are reflective of currently registered application rates. Due to the sampling depth it is not possible to determine how much malathion remained at the soil surface relative to that which moved through the first six inches. Residues detected in the plots in the 6-12" layer after the 2nd, 3rd, 4th, and 5th treatments averaged 35, 37, 5.6, and 9.4 μg/kg, respectively. Malathion was detected in the 12-18 inch soil depth at 16 μg/kg in one replicate soil sample; however, the detection was attributed to contamination. The detection of malathion below six inches along with the low Kd values reported for malathion make it feasible that leaching below 12 inches may have occurred in the field dissipation studies. The terrestrial field dissipation half-life could not be determined due to the rapid dissipation of malathion, although it is probably <1 day (MRID 41748901, 43042401, 43166301). In a field dissipation study located in California, malathion was applied at a maximum rate of 1.16 lbs ai/A once a week for 6 weeks. The resulting dissipation half-life was <0.2 days. In certain instances, malathion was detected below the 12 inch soil depth. No degradates were detected (MRID 41727701, 43042402, 43166301). Malathion dissipation on hard surfaces varies from 0.1 to 2.2 days on concrete to 5.6 to 13 days on sand as seen in **Table B 3-1.1**. Appreciable malaoxon formation relative to malathion concentrations occurred on sand (6%) and dry soil (10%). Residues of malaoxon on steel, concrete, and plastic were very low or nondetectable (MRID 48626701). Degradation of malathion increased over subsequent applications on sand and soil, likely due to microbial activity, but application order appears to have little to no effect on steel, concrete, and plastic and increased formation of malaoxon was not observed.

**Table B 3-1.1. Half-lives of malathion on hard surfaces (MRID 48626701)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Media** | **Application Number** | **Half-life (days)** | **Regression Model of Best Fit** |
| Sand | 1 | 13 | SFO |
| 2 | 7.7 | SFO |
| 3 | 5.6 | IORE |
| Soil | 1 | 4 | SFO |
| 2 | 3.3 | SFO |
| 3 | 2.9 | IORE |
| Steel | 1 | 1.5 | SFO |
| 2 | 3.9 | SFO |
| 3 | 2.6 | SFO |
| Concrete | 1 | 0.1 | SFO |
| 2 | 0.1 | IORE |
| 3 | 2.2 | SFO |
| Plastic | 1 | 0.4 | SFO |
| 2 | 0.4 | SFO |
| 3 | 0.9 | IORE |

Two to three days post-treatment of malathion, malaoxon residues were detected at 0.18 ppm on guava in Hawaii (MRID 44391501), and 0.20 ppm on succulent peas in California (MRID 44205901). Malaoxon levels were <0.01 ppm to 0.10 ppm within days after application on strawberries, blueberries, green onion, and cottonseed (MRIDs 44094401, 43372601, 43383301, 43596601). Over the same interval in the above studies, malathion residues ranged from 0.1 to 12 ppm. Malaoxon formation likely occurs through photo-oxidation in these studies. Open literature studies provide varying rates of terrestrial dissipation. Mulla *et al* (1981) summarizes degradation results from several field studies including: no residues after 6 months (Roberts *et al* 1962), and 85% degradation in 3 days and 97% in 8 days (Lichtenstein and Schulz 1964). The fastest route of terrestrial field dissipation is generally accepted to be microbial degradation.

## Aquatic field dissipation

In the registrant aquatic field dissipation study located in Missouri, malathion was applied at a

maximum rate of 0.58 lb ai/A in three weekly applications to a flooded rice paddy (soil pH 6.1,

water pH not stated). Samples were collected prior to the subsequent weekly application and tested for malathion and malaoxon. Malathion residues detected in water samples collected after the first and second application dissipated to below the detection limit (10 μg/L) in samples taken prior to the second and third applications. In water samples collected one day after the last application, malathion concentrations averaged 17 μg/L and had decreased to 10 μg/L by the second sampling day. Malaoxon residues were <10 μg/L at all sampling dates. The data indicate a very rapid dissipation of malathion in water, with a likely half-life less than one day. An accurate half-life could not be determined because of the rapid dissipation and high detection limit (MRID 42058402, 43166301).

## Spray Drift

A half-acre pond surrounded by cotton fields with a 25 foot buffer was monitored for malathion as part of the Boll Weevil Eradication Program (BWEP) (USDA 1993). Pesticide drift was determined to be the most important mechanism of contamination of the pond. Residue levels in the pond were lower before treatment (<0.1-0.44 µg/L) and higher immediately after malathion application (<0.33-91.4 µg/L). In most cases malathion in the pond degraded to <0.33 µg/L within 7 days. Runoff was only a minor contributor of residue to the pond but only two rainfalls occurred during the sampling period. Other natural bodies of water within treatment areas, but not intentionally receiving direct spray, showed no levels of malathion >0.0154 ppb from 3 to 27 days after applications ceased (USDA 1995). BWEP also assessed spray drift contributions to moving water bodies. Wide buffer strips (125-700 feet) with high vegetation appeared to reduce malathion drift to sensitive areas to levels below detection while narrower and lower buffer afforded less protection. With aerial applications, 8 of 19 applications lead to higher aquatic malathion concentrations, whereas only 1 of 10 ground applications resulted in higher malathion levels. Of the 71 applications for which stream concentrations were measured, the three highest detections were 86.9 ppb, 11.4 ppb, and 10.9 ppb. Aerial applications are more prone to drift than ground applications. Malathion levels in the streams, rivers, and canals increased after nearby treatments and then decreased rapidly. The lower concentrations measured over time are likely due to dilution and in-stream degradation.

Field trials were conducted by Mickle *et al.* (2005) to determine ground deposition following ground and aerial applications of malathion based on the wide-area public health adulticide use in Florida. Peak deposition from the ground and aerial applications were equivalent despite a 4-fold application rate increase for aerial spraying. For ground trials conducted with a volume mean diameter (VMD) of 11 microns, *ca*. 10-50% of the malathion spray was recovered within the 500 m sampling grid, depending on the wind speed. For aerial trials with a release height of 60 meters and a VMD of 32 microns, 35-50% of the malathion spray was recovered within the 5 km grid. Peak deposit levels for ground trials were a maximum of *ca*. 20 gm/ha (32.9% of application rate), and were lower for trials conducted during higher wind conditions, *ca*. 12 kph (7.5 mph), than were for trials conducted during sub-6 kph wind conditions. Peak malathion deposit levels for aerial trials ranged from 6 to 20 gm/ha (2-7.7%), with maximum deposit found 500-1000 m downwind of the flight line.

* 1. **Bioconcentration Factor**

Available octanol-water partition coefficients (Kow) for malathion range from log Kow 2.3-3.3. While a range of Kow values are available for malathion, the Kow value from MRID 00157054 (Kow of 628; Log Kow of 2.8) was chosen to represent Kow for malathion to estimate BCF values and EECs. This is based on the fact that MRID 00157054 tested four different concentrations whereas the other studies only used one or two test concentrations (MRID 40944103 and 4096603) and MRID 40119201 tested a formulated product. As the Log Kow was ≥3, a fish bioconcentration study with malathion was submitted. For fish, a registrant-submitted study (MRID 43106401, 43106402, 43340301) showed that radiolabelled malathion residues did not significantly accumulate in bluegill sunfish exposed to 0.99 μg/L radiolabelled malathion in a flow-through system for 28 days. Average concentrations of malathion were 3.9 to 18 μg/kg in the edible portions of fish, 21 to 130 μg/kg for whole fish, and 34 to 200 μg/kg in the non-edible tissue. Radiolabelled malathion residue equivalents in the edible fish tissue during depuration ranged from 18 μg/kg at the start to 4.8 μg/kg by day 14. Whole fish concentrations decreased from 110 to 4.5 μg/kg and non-edible fish concentrations decreased from 150 to 5.8 μg/kg after day 14. Approximately 73, 96, and 96% of the radioactivity depurated by day 28 from the edible, whole, and non-edible portions of fish, respectively. The only residue detected in fish tissue at >10% of total radioactive residues (TRR) was malathion monocarboxylic acid (MCA) in concentrations of 33.3-35.9% (44.8-61.2 μg/kg) of TRR. Up to 22 other components were present in levels of 0.1 to 5.7% (0.1 to 7.7 μg/kg) including malathion dicarboxylic acid (DCA), malaoxon, desmethyl malathion, monoethylfumarate, and oxalacetic acid. Malaoxon was present in concentrations ≤2.7 μg/kg; while parent malathion was present in concentrations of 0.2 μg/kg at the end of the depuration period. Bioconcentration factors (BCFs) were calculated using the average malathion tissue concentration divided by the water concentration; often BCFs are reported unit less, but they are sometimes reported as L/kg-wet weight. Maximum BCFs, as a function of total radioactive residues present, ranged from 4.2 to 18, 23 to 135, and 37 to 204 for the edible, whole fish, and non-edible portions of fish, respectively; the maximum BCF value for whole fish, based on malathion concentrations, was 131 (130 µg/kg ÷ 0.99 µg/L).  Additionally, in the laboratory study by Kanazawa (1975, (ECOTOX #2164), freshwater fish (*Pseudorasbora parva*), were exposed to an initial concentration of 1.2 ppm malathion and tissue concentrations decreased to 0.001 ppm after 7 days. After three days, a BCF value of 2 was reported. In another laboratory study by Walsh and Ribelin (1975), both male and female coho salmon (*Oncorhynchuss kisutch*) and lake trout (*Salvelinus namaycush*) were exposed to malathion until death occurred or was imminent (up to 30 days) after which a necropsy was performed and approximately half of the fish was frozen and subsequently analyzed for pesticide residues. According to the study, the concentration of malathion at test termination was 0.178 ppm (however, the exposure concentration of malathion may have increased over the test duration from 0.06 to 0.178 ppm). Tissue concentrations in coho salmon and lake trout were reported as 1.31 and 5.22 ppm, respectively, resulting in test termination BCF values of 29.3 and 7.36, respectively.

For aquatic invertebrates, malathion concentrations in water and shrimp tissue after aerial application to a saline marsh in Texas were examined in Conte and Parker, 1975. Juvenile brown (*Penaeus aztecus* Ives) and white (*P. setiferus*) shrimp, kept in cages, were exposed to technical grade malathion (with no carrier), after which malathion concentrations in the water as well as in both dead and live shrimp were monitored for either up to 24 or 48 hours. Measured malathion concentrations in water were sampled during the 24 or 48-hour monitoring period and ranged from 0.8 – 3.20 ppb with concentrations generally reducing over time. Shrimp mortality in the treated areas ranged from 4% up to 72% (based on reported mortality in individual cages). Malathion concentrations in shrimp tissue (from abdominal muscle) sampled at the same time points as the water were reported to range from 300 to 2,700 ppb (0.3 to 2.7 ppm). Malathion was not found in the water or shrimp tissue at the control site, and there was no observed mortality. In the laboratory study by Ashauer *et al*. 2012 (ECOTOX# 160013, 153560), the freshwater amphipod, *Gammarus pulex*, was exposed to malathion via water for 24 hours with a six day depuration phase. Both parent malathion as well as metabolites (including the oxon) were measured. The reported 24-hr BAF (bioaccumulation factor) was 3 and included residues for malathion and malaoxon. Finally, uptake of malathion was examined in freshwater plants including the parrot feather (*Myriophyllum aquaticum*), duckweed (*Spirodela oligorrhiza L*.) and elodea (*Elodea Canadensis*) (Gao *et al.* 2000; ECOTOX# 68281). The plants were exposed to analytical grade (>99%) malathion in water for eight days after which residues were measured. The reported 8-d BCF values were 3.0, 23 and 1.2 for the parrot feather, duckweed, and elodea, respectively.

The studies discussed above were considered when determining the bioconcentration/bioaccumulation input parameter for calculating malathion residues in aquatic organisms for evaluating risk (via aquatic prey items) to aquatic-dependent terrestrial animals. Laboratory studies with fish report BCF values for whole fish, edible and non-edible portions from 2-204. In the registrant-submitted fish study, the whole fish BCF is 131, based on malathion concentrations. The maximum reported whole fish BCF value (which was from registrant-submitted study) is 135 which is based on total radioactivity. In the other available studies, the exposure concentrations degraded over time (Kanazawa, 1975, E2164) or residue samples were sometimes measured in dead fish for which fish were cut in half and analyzed (Walsh and Ribelin (as cited in The Pathology of Fishes 1975)).

The KABAM (Kow (based) Aquatic BioAccumulation Model)-estimated time to steady-state (based on log Kow of 2.8) for malathion is 2 days. KABAM-derived BCFs for fish, based on log Kow of 2.8 is 31. These estimates are based on the assumption that malathion is not metabolized by fish for which information is available to indicate malathion is metabolized and excreted by animals (MRID 41367701). Considering both the empirical and estimated BCF data for fish, the whole fish BCF value of 131 from the registrant submitted study will be used to estimate malathion concentrations in fish because exposure was constant and residues were characterized and conducted using live fish.

For aquatic invertebrates, water-column exposure BCF/ and BAF values were available for shrimp and amphipods. In the field study with shrimp (Conte and Parker, 1975), malathion concentrations in tissue and water were measured at various intervals over a 24 or 48 hour period after an aerial application. In this study, based on reported residues of up to 4 live shrimp, BCF values were approaching 400 after 1 hour of exposure and up to and over 1000 by 3 or 9 hours, with a maximum BCF of around 1600 after 24 hours exposure. BCF values of this magnitude and this quickly after exposure are not anticipated based on data from other studies and estimated values for other aquatic organisms In the amphipod study, the 24-hr BAF value (which was comprised of residues for both malathion and malaoxon) was 3 (Ashauer *et al.* 2012). Given that exposure in the amphipod study was only for 24-hours, residues may not have reached steady-state based on the estimated time to steady-state of 2 days. In a study evaluating uptake in snails exposed to malathion- treated sediment, the reported BCF values were approximately 5-50 (Martinez-Tabche et al. 2002, E67329). However, in another figure in this study reporting measured concentrations in snails and sediment, it appears the highest BCF would be about 5 and not 50. The KABAM estimated BCF values for aquatic invertebrates range from 16-24, based on Log Kow value of 2.8. While the KABAM estimate may not consider metabolism rates, given the uncertainties in the empirical data, the upper end estimate of 24 will be used to estimate concentrations in aquatic invertebrates.

For aquatic plants, there was one study which evaluated residues in three plant species after 8 days of exposure with reported BCF values of 1.2-23. The KABAM estimated BCF value is 31, based on Kow value of 2.8, for aquatic plants (phytoplankton). The 8-day exposure is greater than the time to reach steady-state and the highest reported BCF value of 23 will be used to estimate residues in aquatic plants.

Several studies related to bioaccumulation of malathion that were identified using ECOTOX are not included in this analysis (Table A.10). Reasons for exclusion included the following:

1. Studies that reported BCFs or BAFs that were not whole organism (e.g., tissues or organs);
2. Studies that were based on total radioactive residues, and did not distinguish between malathion and degradates that are not residues of concern;
3. Exposures to non-aquatic organisms (e.g., soil-exposure to earthworms).

Table A.10. Studies in ECOTOX that were excluded from bioconcentration analysis

|  |  |  |
| --- | --- | --- |
| Citation | ECOTOX # | Reason for exclusion |
| Belluck D;Felsot A. 1981. Bioconcentration of Pesticides by Egg Masses of the Caddisfly, Triaenodes tardus Milne. Bull. Environ. Contam. Toxicol. 26: 299-306 | 2340 | 2 |
| Hassan IM;Abdallah MA;Naguib MM;Abou Donia MA. 1993. Toxicity, Distribution, Accumulation and Cooking Loss of Malathion in Tissues of Tilapia and Common Carp Fishes. Grasas Aceites 44(6): 339-344 | 89874 | 1 |
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| Henson-Ramsey H;Levine J;Kennedy-Stoskopf S;Taylor SK;Shea D;Stoskopf MK. 2007. Development of a Dynamic Pharmacokinetic Model to Estimate Bioconcentration of Xenobiotics in Earthworms. Environ. Model. Assess. 14(3): 411-418 | 121165 | 3 |
| Henson-Ramsey H;Shea D;Levine JF;Kennedy-Stoskopf S;Taylor SK;Stoskopf MK. 2008. Assessment of the Effect of Varying Soil Organic Matter Content on the Bioavailability of Malathion to the Common Nightcrawler, Lumbricus terrestris L. Bull. Environ. Contam. Toxicol. 80(3): 220-224 | 104629 | 3 |

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fresh water fish, motsugo, *Pseudorasbora parva*. Bull. Environ. Contam. Toxicol. 14(3):

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