ENVIRONMENTAL FATE OF THIOBENCARB

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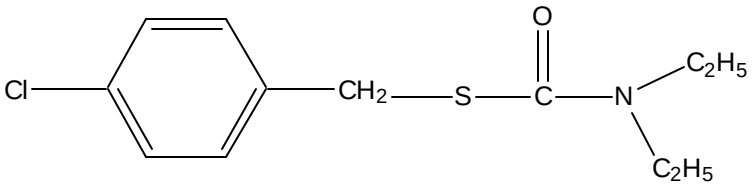
S-[(4-chlorophenyl) methyl]diethylcarbamothioate

$C_{12}H_{16}ClNOS$



M.W. 257.8

General information

This document reviews the environmental fate and environmental effects of the thiocarbamate herbicide, thiobencarb {S–[(4-chlorophenyl) methyl] diethylcarbamothioate ($C_{12}H_{16}ClNOS$)}. Thiobencarb, also referred to as benthiocarb was developed by Kumiai Chem. Ind. Co. Ltd and introduced in the market in 1970 (Ishikawa, 1981). It was introduced in California as the active ingredient of the rice herbicides Bolero® and Abolish®. Bolero® is a granular/flake herbicide which is applied to rice field water post-flood. Abolish® is an emulsifiable concentrate herbicide, applied pre-plant, pre-flood directly to the soil, or post-flooded, post-emergence to drained fields. Both products are applied at an application rate of up to four pounds active ingredient per acre. Both have a narrow window of application (after rice plant grows to 1 1/2 leaf stage, and after watergrass or barnyardgrass grows past the 1 1/2 leaf stage), and applied primarily by air (Newhart, 2000).

Table 1: Physico-Chemical Properties

Chemical Abstract Registry (CAS) #	28249-77-6
Molecular formula	$C_{12}H_{16}ClNOS$
Molecular weight	257.8
Physical State	Granular/Emulsifiable
Boiling point	127^{o} – 131^{o}C (0.12 mm Hg)
Vapor Pressure[1]	1.5×10^{-5} torr @ 20^{o}C
Specific gravity	1.15
Water solubility[2]	30 ppm
Henry's law constant[2]	2.7×10^{-7} atm m^3/mol
$K_{O C}$[2]	1380
K_{ow}[2]	2630
Hydrolysis $t_{1/2}$	>100 days
Photolysis in water (pH 7)	190 days @ 25^{o}C
Photolysis in soil	168 days
Aquatic half-life $t_{1/2}$[3]	8.7 days
Aerobic soil metabolism $t_{1/2}$	40 days
Anaerobic soil metabolism $t_{1/2}$	300 days
Field dissipation half-life $t_{1/2}$	21 days
Calculated BCF[2]	234

[1]Seiber el al (1986)

[2]S.A. Mabury et al (1996)

[3]M.D. Ferrando et al. (1992)

***** All other data from U.S.EPA RED sheet, 1999.***

Ecological Effects (USEPA, 1999)[3]

Table 2: Animal Toxicity

Acute Oral LD_{50} (male rats) 8 EC	2810 mg/Kg
Acute oral LD_{50} (female rats) 8 EC	1340 mg/Kg
Acute Oral LD_{50} (male & Female rats) 10% granules	>5000 mg/Kg
Acute Dermal LD_{50} (Rabbit) 8 EC	>2,025 to <10,250 mg/Kg
Acute dermal LD_{50} (Rabbit) 10% granules	>5000 mg/Kg

[3]U.S.EPA RED sheet, 1999

Table 3: Thiobencarb toxicity to selected organisms[4]

Species	Test (LC_{50})	Toxicity
Ceriodaphnia dubia (water flea)	48-hr	0.51ppm
Daphnia magna (water flea)	48-hr	1.2 ppm
Gammarus pseudolimnaeus (side-swimmers)	96-hr	1.0 ppm
Orconectesnais (Cray fish)	96-hr	2.0 ppm
Procambarus clarki (Cray fish)	96-hr	6.5 ppm
Salmo gairdneri (rainbow trout)	96-hr	1.2 ppm
Ictalurus punctatus (channel fish)	96-hr	2.3 ppm
Lepomis macrochirus (bluegill sunfish)	96-hr	1.7 ppm
Mysid (shrimp)	96-hr	0.33 ppm
Leuresthes tenuis (California grunion)	96-hr	0.24 ppm
Menidia menidia (silverside)	96-hr	0.20 ppm
Menidia penisulae (silverside)	96-hr	0.46 ppm
Striped bass	96-hr	0.14 ppm
Selenastrum capricornutum (green algae)	72-hr EC_{50}	20.3-38.6ppm

[4] ***S.A Mabury et al (1996)***

Table 4: Toxicity to Birds[5]

Species	Test	Toxicity
Northern bobwhite quail	Oral LD_{50}	>1938 mg ai/Kg
Northern bobwhite quail (sub-acute)	Dietary LC_{50}	5620 ppm ai
Northern bobwhite quail (chronic)	Reproduction: NOEC	267 ppm ai
Japanese quail (chronic)	Reproduction: NOEC	750 ppm ai
Mallard duck	Reproduction: NOEC	100 ppm ai
	Reproduction: LOEC	300 ppm ai

[5] ***USEPA R.E.D (2000)***

Mode of action

Thiobencarb is a thiocarbamate herbicide. The expected site of activity for thiocarbamate herbicides is in the aboveground meristematic tissue (Ashton et al., 1981). When applied thiobencarb is absorbed by roots and shoots of grass seedlings, and then translocates upward in the apoplast to locations where it inhibits cell division and enlargement (Jordan & Codney, 1987). Thiobencarb is a systematic, pre-emergence herbicide that acts by inhibiting shoots of emerging seedlings (U.S EPA, 1997). Shibayama et al. (1976) treated developing barnyard grass and bearded sprangletop with thiobencarb to conduct morphological studies and reported severe malformations of leaves while still within the coleoptile, and kinking of the first internodal region occurred. It controls many annual grasses and some selected broadleaves, with good selectivity between rice and weeds (Reiners et al; 1988; Ishikawa, 1981; Valent USA, 2000). Reiners et al. (1988) examined differential levels of tolerance to thiobencarb in soil and nutrient assays between two lettuce cultivars, and found that the more susceptible cultivar showed significantly more inhibition in foliar growth than the tolerant cultivar.

Fate and Behavior of Thiobencarb Herbicide in Biota and the Environment

Fate in Air

Thiobencarb volatilizes slowly, yielding low concentrations in air over time. Evaporation percentages of 0.90% and 0.10% have been reported a few days after application to rice water (Ross et al., 1984). Thiobencarb has a relatively low vapor pressure ($1.5x10^{-5}$ torr @ 20°C) and thus volatilization is a minor form of transport. A moderately small Henry's law constant (2.7×10^{-7} atm m^3/mol) indicates it has low escaping tendency from aqueous solution. Drift may be an issue with thiobencarb as it is applied by aircraft near waterways.

Fate in Water

Pack (1974) conducted a study to determine the stability of thiobencarb in water. To each, 500 ml portion of Robinson's phosphate-borate buffer (5.0, 7.0, and 9.0) in triplacate, they added 1ml ethanolic solution of thiobencarb (2.5mg/ml) sealed and kept them in the dark at 25°C. They withdrew two-ml aliquots from each of the containers. They then placed the aliquots in test tubes and added 3 ml of N-potassium hydroxide solution, then 5 ml of n-hexane containing 2 ppm of 3,4-dichlorobenzyl N, N-diethylthiolcarbamate as an internal standard was added and the mixtures shaken well. The n-hexane layers were analyzed for thiobencarb. Over a 160-day period, the authors recorded the concentration of thiobencarb at day 0, 21, 42, 84, 125, and 160 and found no measurable hydrolysis of the herbicide under all three pH's. From this study, it was reported that thiobencarb is stable to hydrolysis.

Cheng (1976) conducted photodegradation study with [RING - ^{14}C] thiobencarb in water, on a glass plate, and on soil TLC plate. In the study thiobencarb readily degraded when exposed to either sunlight or short wavelength ultraviolet light (254 nm). It was degraded much faster though by ultraviolet light than by sunlight. It was also found that thiobencarb degraded faster in water or on a glass surface or silica gel surface than on soil surface. The half-life of thiobencarb exposed to ultraviolet light was reported as 1, 1.5, 2, and 20d on glass surface, in water, on silica gel TLC plate, and on soil TLC plate, respectively. Thiobencarb when it was exposed to sunlight, had a reported half-life of three days. Thiobencarb was found to decompose into several products after exposure to sunlight including benthiocarb sulfoxide and desethyl benthiobencarb.

Ferrando et al. (1992) studied the persistence of thiobencarb in the aquatic environment. They particularly measured the persistence of the pesticide in natural water, from Albufera Lake (Spain), and in experimental water from their laboratory. They conducted their experiment in 20 L glass aquaria (UV transmittance) containing a fixed amount of thiobencarb in 15 L of each medium, using 0.2 ppm for thiobencarb. They found thiobencarb to be very stable in both environments. Reported half-lives were 74.7 and 247.66 hours in natural and experimental medium, respectively. They indicated in their conclusion that microbial breakdown of thiobencarb in natural water may be speeding up the degradation process in this medium.

Fate in Soil

The K_{ow} for thiobencarb is relatively high (2630) and the water solubility (2750 ppb) relatively low and thus tends to partition to soil. Thiobencarb is not very mobile generally, has a tendency to bind to soil organic matter, and fails to desorb easily from the soil column (U.S.EPA, 2000). Ross et al. (1984) showed thiobencarb to be persistent in soil, as they found sixty-one percent of peak soil concentration (2329 ppb) to still be present one month after the chemical was applied to a rice field. Ross and Sava (1986) analyzed soil, water, vegetation and air samples taken from two Glenn county commercial rice fields, and found higher thiobencarb concentration in soil than in any of the other media.

Braverman et al. (1990) conducted sorption and degradation studies to characterize the adsorption-desorption and degradation of thiobencarb on three Florida soils (Pahokee muck, Everglades muck, and Immokalee sand). They found that thiobencarb adsorption on soil was correlated with soil organic carbon. The adsorption values (ml g^{-1}) per unit of organic carbon were 1195, 765, and 539 for Immokalee sand, Pahokee muck, and Everglades muck, respectively. The Pahokee muck, Everglades muck, and Immokalee sand adsorbed 97, 94, and 56% of the ^{14}C-thiobencarb out of solution respectively. Desorption (K_f) values were in the order Pahokee muck > Everglades > Immokalee sand and these were inversely proportional to the percent removal from soil (desorbed).

They found that soil series, temperature, and soil water tension interacted in their effects on thiobencarb degradation. When the soil was incubated at 25^{o}C, the half-lives of thiobencarb were similar on the Pahokee and Everglades muck (18.5 days) and were shorter on the mucks than on the Immokalee sand (27 days). With the soil incubated at 35^{o}C, the half-life of thiobencarb was longer on the Everglades muck (14 days) than the Pahokee muck (18 days) and was shorter on the mucks than on the Immokalee sand (21.5). Thiobencarb was degraded faster in all three soils incubated at 25 or 35oC under moist conditions (10 kPa) than dry conditions (100kPa).

Nakamura et al. conducted a study to determine the degradation of thiobencarb in soils as affected by soil conditions. The degradation rates of 14C-thiobencarb in three soils under upland, oxidative flooded, and reductive flooded conditions were compared. They found that the rate of disappearance of thiobencarb in the soils tested were not extremely different. However, they found extreme differences among different conditions of the soil, with faster degradation of the herbicide occurring under upland condition in all three soils and to a lesser extent under oxidative flooded conditions. The slowest degradation occurred under reductive flooded condition. The half-life period was calculated to be around 20, 50, and 200 days under upland, oxidative flooded, and reductive flooded conditions, respectively.

Johnson & Lavy (1994) conducted a study to determine the in-situ dissipation of thiobencarb at three depths in a typical rice growing soil (Stuttgart, AR.). They found that thiobencarb dissipation was significantly affected by depth in the soil profile. They calculated a DT_{50} value of 54 days at 2-cm depth and found slower dissipation rate (94 days) at the 60-cm depth where the soil was wettest.

Mobility of thiobencarb was also studied by Warnock (1974) in four typical soils (two soils: Stockton adobe and Louisiana silty clay loam; Norwalk silty clay loam; Oakley sandy loam, from California) using thin-layer chromatography techniques. According to this study, thiobencarb moved very little in the soil. In three of the four soils, the Rf of thiobencarb was less than 0.09, placing it on Helling and Turner's mobility class 1.

Braverman et al. (1990) conducted a laboratory and greenhouse study as well, to determine the mobility and bioactivity of thiobencarb on a Pahokee muck, Everglades muck, and Immokalee sand. Movement of thiobencarb by leaching the soil columns with 0.01 N $CaCl_2$ to a 20-cm depth was minimal, according to the authors. In the Pahokee muck 98.7% of the ^{14}C-thiobencarb remained in the top one-centimeter and 1.3% was found in the one to two centimeter depth. In the Everglades muck 99.2% of the ^{14}C-thiobencarb remained in the top one-centimeter soil segment. The herbicide was slightly more mobile in the Immokalee sand where 94% remained in the top one centimeter of soil as five percent leached to the one to two centimeter depth.

Lai (1991) conducted a field study on the dissipation of Bolero® 8EC in a rice field soil in Port Barre, Louisian. Bolero 8EC was applied to rice plants at the rate of four pounds active

ingredient per acre. Flush irrigation was applied once three days after application. The plots were permanently flooded to four and a half inches and maintained under flood for 75 days.

Samples were collected at two, three, four, five, six, eight and ten months after application. At each sampling interval, three cores were collected from a designated subplot in each of five replicates of the treated soil. When the samples were received at the laboratory, they were cut into smaller depth segments, 0-5 cm, 5-10 cm, 10-15 cm and so forth. The segments were composited into single cores for each of the five replicates and analyzed.

Total residues in the soil (all depths) were calculated as residues in the top 0-5 cm soil segment. Log-linear least squares regression analysis of the data resulted in estimated half-life values of thirty-six days, 1.3 days and 6.5 days, respectively, for thiobencarb, thiobencarb sulfoxide and 4-chlorobenzylmethylsulfone. Thiobencarb was found as the major residue with a maximum level of 0.92 ppm, dry weight basis, five days after application. Thiobencarb sulfoxide and 4-chlorobenzyl methyl sulfone were also found, reaching maximum residue levels of 0.24 and 0.05 ppm, respectively, three days after application. The residues of all three analytes were found primarily in the 0-5 cm depth segment. In this study, no residues of any of the analytes were found below the 0-15 cm depth segment of the soil.

Pack (1974) conducted a study to determine metabolism of [ring-U-^{14}C]thiobencarb in two rice growing soils (California and Louisiana) at initial concentrations of six ppm under both aerobic-no-flooded and anaerobic-flooded conditions. In their study, thiobencarb degraded under aerobic conditions with half-lives of two to three weeks. Over 90% of the herbicide degraded within 120 days even in the slower samples. Under anaerobic conditions the rate of degradation was slower, with a half-life of eight months for the California soil and six months for the Louisiana one. Carbon dioxide was a major metabolite they observed under aerobic conditions and the only volatile one.

Besides CO_2, however several other metabolites were observed: Desethyl benthiocarb, 4-chlorobenzoic acid, 2-hydroxy bethiocarb, benthiocarb sulfoxide, 4-chlorobenzyl methyl sulfoxide, 4-chloro methyl sulfone, and 3-hydroxy benthiocarb. 2-hydroxy benthiobenthicarb and 3-hydroxy benthiocarb were only seen in the anaerobic samples. The major metabolite was 4-chlorobenzyl methyl sulfone which reached a maximum concentration of five percent of the dose. The second major metabolite was bethiocarb sulfoxide. All of the metabolites, both under aerobic and anaerobic conditions, reach a maximum, and then themselves degrade to very low values by one year.

Ruzo et al. (1988) conducted a study to determine the photoreactions of [^{14}C]thiobencarb herbicide under natural sunlight, on a sandy loam surface from a Sacramento rice growing area. The study was conducted at a maximum field application rate of six pounds per acre active ingredient. Soil samples from Sacramento, Calif. were exposed to natural sunlight for up to 30 days using a specialized apparatus with temperature-controlled chambers which are covered with quartz plates for the light exposed set and normal glass plates covered with dark material to prevent exposure for the dark set. The temperature was continuously monitored and recorded at 20-minute intervals throughout the study. Sunlight intensity and cumulative sunlight energy were also measured and recorded at 20-minute intervals throughout the study.

Soil was extracted with acetone three times and water three times. Combined extracts were examined by LSC and HPLC. The soil, after extraction, was combusted and the radiocarbon quantitated by LSC. Thiobencarb was identified by HPLC and TLC. CO_2 was also detected in small quantities. The major degradation products observed in all samples, light and dark, were 4-

chlorobenzoic acid that reached a maximum of 1.3% of the initial applied [^{14}C]. The photodegradation half-life was reported as 167.9 days. The half-life of thiobencarb calculated for the dark control was 280.3 days. The products observed in both the light and dark samples were 4-chlorobenzoic acid and CO_2, both detected in small yields.

Fate in Biota

Toxicity to Animals:

Thiobencarb is toxic to rats at dietary concentrations of 100 ppm. It causes decreased body weight gains, food consumption and food efficiency, as well as increased blood urea nitrogen (U.S. EPA, 1999) at this concentration. At a dietary concentration greater than 100ppm thiobencarb can impair reproduction in some birds (U.S. EPA, 1999). Thiobencarb is currently assumed to pose minimal risk to bees because it is used on sites that are not expected to result in significant exposure to them (U.S. EPA, 1999).

Based on U.S. EPA's classification thiobencarb is moderately toxic to fish, highly toxic to aquatic invertebrates, and acutely toxic to marine estuarine fish and mollusks (U.S. EPA, 1999). According to Villalobos et al. (1998), the earlier in development that fish are exposed to thiobencarb, the greater the toxicity. Thiobencarb is detrimental to the survival and reproduction of fresh water invertebrates at aqueous concentrations greater than ten parts per million. It can adversely affect the growth of juvenile fish at a concentration of 150 ppm (U.S. EPA, 1999).

Tsuda et al. (1997) studied acute toxicity, accumulation, and excretion of thiobencarb and its degradation products in Killifish. The fish were exposed to a range of concentrations of thiobencarb, 4-chlorobenzyl alcohol, and 4-chlorobenzaldehyde (each in one liter of test solutions in beaker) for 48 hours under static conditions at 21^{o}C. The concentrations tested were 1.5, 2.4, 3.9, 6.3, and 10 ppm for thiobencarb, 7.6, 12.2, 19.5, 31.3, and 50 ppm for 4-chlorobenzyl alcohol, and 1.5, 2.4, 3.9, 6.3, and 10 ppm for 4-chlorobenzaldehyde.

For the accumulation test (96 hours) they diluted 800 ppm of thiobencarb, 400 ppm 4-chlorobenzyl alcohol and 400 ppm of 4-chlorobenzaldehyde 25 times with dechlorinated city water and supplied by continuous flow to each of three aquaria containing 250 fish each. The concentrations of the chemicals in each exposure tank were 11.0, 7.1, and 4.4 ppm for thiobencarb, 4-chlorobenzyl alcohol, and 4-chlorobenzaldehyde, respectively. They measured the chemical concentrations at 0, 6, 12, 24, 48, and 96 hours, respectively and took out twenty fish at each time interval. All of the fish were frozen were frozen and preserved for analysis after rinsing with distilled water.

For the excretion test (12 hour), they transferred about 100 fish remaining in each tank separately into each of the other three aquaria and supplied each with dechlorinated city water. Twenty fish were taken at 3, 6, and 12 hours, respectively. All of the fish were frozen were frozen and preserved for analysis after rinsing with distilled water.

The reported values of the 24-hour LC50 and 48-hour LC_{50} were 10, and 4.1 ppm for thiobencarb, 58 and 44 ppm for 4-chlorobenzyl alcohol, and 7.6 and 7.6 for 4-chlorobenzaldehyde, respectively. The concentrations of chemicals in Killifish at hour zero were reported as equal to those at hour 96 in the accumulation tests. The excretion rate for 4-chlorobenzyl alcohol was reported slightly slower than that of thiobencarb. The rate for 4-chlorobenzaldehyde could not be measured but presumed to be faster than that of 4-chlorobenzyl alcohol. It is thus suggested in this study that thiobencarb degradation products are safer than the parent compound in the water environment.

Wany et al. (1992) conducted a study bioconcentration and excretion of thiobencarb in fish, clam, and shrimp. For the test, organisms were placed in a 500-L tank that received clean water amended with thiobencarb. The aqueous solution was renewed every two days. Uptake and depuration tests were continued for thirty days. Depuration tests were performed by removing the test organisms, three days after the uptake test.

For both the uptake and depuration tests, six test organisms were randomly sampled from the experimental tank on 0, 1, 3, 5, 7, 10, 15, 20, 25, and 30 days and analyzed. The study results were summarized in the tables below:

Table 5: 48-hour LC_{50} value (mg/L)

Organism	Concentration (ppm)
Carp	1.93
Tilapia	1.99
Loach	2.54
Grass Carp	1.51
Eel	0.89
Black Silver Carp	2.45
Fresh water clam	>20
Macrobranch shrimp	3.47

Table 6: Maximum accumulation (within 3 to 5 days exposure) in organisms and bioconcentration factor (BCF)

Organism	Herbicide in water(ppb)	Maximum accumulation in organism (ppb)	BCF
Carp	27.9	1439	48.5
Tilapia	11	254	17
Loach	11	320	22.2
Grass Carp	11.25	107	10.1
Eel	7.7	125.5	17
Black Silver Carp	3.2	1549.5	624.5
Fresh water clam	110	375.5	5.1
Macrobranch shrimp	27.5	0.15	0.01

[6] Wany et al. (1992)

It was reported that more than half of the herbicide residue in carp, tilapia, loach, clam and black silvercarp was excreted within five days in clean water. After thirty days, only a slight residue was found; 19.1, 2.8, 3.1, 10.2, and 629 ppb for Carp, tilapia, loach, clam, and black silver carp, respectively. In macrobranch shrimp, grass carp, and eel, negligible or nondetectable amounts were found within three days in clean water.

Fernandez-Vega et al. (1999) conducted a study to determine thiobencarb toxicity and plasma AChE inhibition in the European Eel. The 24, 48, 72, and 96 hours median lethal concentrations (LC_{50}) were 25.7, 21.7, 17.0, and 13.2 ppm, respectively. Fish were also exposed to a sublethal thiobencarb concentration ($1/_{60}$LC50-96 hr=0.22 ppm) during 96 hours in a flow-through system and then an elimination period of 192 hours in clean water was allowed.

Eels were removed and blood and blood samples taken out at each exposure time and recovery period in order to evaluate AChE activity. Thiobencarb was found to induce significant inhibitory effects on plasma AChE activity on European Eel from the first contact time and with thiobencarb sublethal concentration.

Persichino et al.(1998) conducted a study to determine the effect of Bolero® 8EC on the gill apparatus of a small number of Mosquitofish. In two trials, Mosquitofish were exposed to varying concentrations of Bolero 8EC. In the first trial groups of three mosquitofish were exposed to 0, 576, 1200, and 1800 ppb of the herbicide. In the second trial groups of three mosquitofish were exposed to 0, 19, 90 ppb of the herbicide. The Mosquitofish were removed from each exposure medium on the seventh day or before if dying. From the right side of each fish, each gill apparatus consisting of four-gill arches was removed. Microspic tissue samples were prepared, stained, and observed under the light microscope. A total of 168 gill arches were examined along with their primary and secondary lamellae.

A significant inflammatory response was detected in all fish exposed to Bolero® 8EC. More gill lesions were observed and they became severe at higher concentrations, it was reported. It was observed that more Mosquitofish in the 1200 and 1800 ppb exhibited "moribund" states before the seventh day. All Mosquitofish were observed to be healthy after seven days of exposure.

Reiners et al. (1987) conducted a study to characterize, quantify, and contrast the metabolism of 14C-thiobencarb in two lettuce cultivars Dark Green Boston (BOS) and Great Lakes 366 (GLA). They observed a significant difference in the level of tolerance to thiobencarb in the two cultivars. There was an evident reduction in leaf tissue dry weight in the thiobencarb treated BOS compared to the untreated control. No differences were found in the root system of either cultivar in response to thiobencarb treatment suggesting the primary site of activity is the developing leaf. Concentrations of thiobencarb in this tissue may thus be critical for development of phytotoxicity.

Conclusion

Thiobencarb belongs to the group of herbicides known as thiocarbamates. It is the active ingredient in the herbicides Bolero® and Abolish®. It kills weeds by inhibiting cell division and enlargement in the roots and shoots of the seedling plants. Since it has a relatively low small Henry's law constant, combined with low vapor pressure, thiobencarb has a weak tendency to partition into the atmosphere. Thiobencarb is stable to hydrolysis and to anaerobic aquatic metabolism.

Thiobencarb has a relatively short half-life in the aquatic environment. Aquatic half-life has been reported as five to ten days. In the presence of light, thiobencarb photodegrades into 4-chlorobenzoic acid, 4-chlorobenzaldehyde, 4-chlorobenzyl alcohol, and N, N-diethyl-4-(chlorobenzyl thiocarbamate)S-oxide.

Thiobencarb displays relatively strong sorption to soil. Thiobencarb has been reported to be very limited in mobility. According to the studies presented in this report, thiobencarb has not been found below the 0-5 cm layer of soil. Soil series, temperature, and water content have been found

to have an effect on thiobencarb degradation. For example it was found to degrade faster under moist condition than under dry condition. It has been found to accumulate in some aquatic organisms such as killifish, clam and eel. After it accumulates in certain organisms, thiobencarb is excreted to a negligible to non-detectable amount in the tissues. It is classified by U.S. EPA as moderately toxic to fish

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