Relationships Between Pond Sediments and Simazine Loss from Waters of Laboratory Systems[1]

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INTRODUCTION

Certain physical and chemical properties of agricultural soils greatly influence the activity and persistence of soil-applied herbicides (11, 14). Knowledge of these interactions permits more efficient and economic usage patterns and effective weed control. Similar information on the relationships between characteristics of ponds and aquatic herbicide behavior is largely lacking. Studies conducted in ponds have indicated that the character of the sediment, especially the organic matter and clay content, may influence the persistence and herbicidal activity of certain herbicides (3, 4, 9).

Simazine [2-chloro-4,6-bis(ethylamino)-*s*-triazine] has found some acceptance as a broad spectrum herbicide for use in fish ponds. Various values have been reported for the persistence of simazine in ponds (7, 10, 12) but there has not been enough information presented to allow postulation of the factors affecting the rate of herbicide loss from pond waters. This investigation was conducted to determine the importance of sediment on the loss of simazine from

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waters in laboratory systems. The relationships between selected sediment physico-chemical characteristics and the rate of simazine loss from water are also reported.

METHODS AND MATERIALS

Sixteen sediment samples were collected from central Alabama ponds using an Ekman dredge. Each sample was assigned a number (1 to 16). Subsamples of each sediment were air-dried and pulverized with a mortar and pestle for the determination of organic matter, cation exchange capacity, and pH. Percentage organic matter was determined by the Walkley-Black dichromate oxidation method (5). Cation exchange capacity was estimated by ammonia saturation and sodium chloride displacement (5). Sediment pH was measured in 1:1 (w:v) suspensions of sediment and distilled water. Particle size analyses were made using the rapid hydrometer method given by Weber (13) without removal of organic matter by H_2O_2 oxidation. Particle size analyses were made using wet sediment with results corrected for water content.

The importance of the presence of sediment on the persistence of simazine was investigated using three sets of laboratory systems. Each set consisted of four 250-ml flasks; two with 200 ml of one of three pond waters and two with 200 ml of pond water plus 30 g (air dry basis) of sediment sample number 4. Analyses of the pond waters for chemical oxygen demand, total alkalinity, and pH were conducted using standard methods (2). One week after the systems were set up, technical grade (97.7%) simazine dissolved in 95% ethanol was added giving a final simazine concentration of 3 mg/l. Flasks were slowly rotated (50 rpm) on a rotary shaker in a dimly-lit room maintained at 25±2 C. At 32 days after treatment, simazine remaining was determined by the pyridine-alkaline-ethyl-cyanoacetate (PAE) spectrophotometric method (8).

Sixteen systems were used to investigate the relationship between selected sediment physico-chemical characteristics and the rate of simazine loss from water. Each system contained one of the 16 sediments and 200 ml of distilled water in a 250-ml flask. Sediment, water, and simazine were added as above. Simazine remaining at 1, 4, 8, 16, and 32 days after treatment was determined by the PAE method.

RESULTS AND DISCUSSION

In systems with pond water alone a maximum of 20% of the simazine was lost from the water 32 days after application (Table 1). In systems containing water and sediment more than 75% of the simazine was lost from the water in the same period. Possible fates of simazine lost from the waters of these systems include adsorption to clays or organic matter, chemical decomposition, microbial decomposition and uptake by phytoplankton (6, 10). A greater loss of simazine in the presence of sediment is not unexpected because the surface area for sorption processes is obviously much greater when sediment is present and microbiological activity is usually greater in sediments than in the overlying water because of the accumulation of metabolizable organic matter. It is to be emphasized that in flasks containing water and sediment, we measured only loss

TABLE 1. SELECTED WATER QUALITY CHARACTERISTICS OF 3 POND WATERS AND THE SIMAZINE REMAINING 32 DAYS AFTER TREATMENT OF FLASKS CONTAINING POND WATER ALONE OR POND WATER AND SEDIMENT. THE ORIGINAL SIMAZINE CONCENTRATION WAS 3.0MG/L. EACH VALUE IS THE AVERAGE FOR DUPLICATE SYSTEMS.

Water	pH	Chemical Oxygen Demand (mg O_2/l)	Total Alkalinity (mg/l $CaCO_3$)	Simazine Remaining	
				Water (mg/l)	Water + sediment (mg/l)
1	6.3	12.5	9.6	2.9	0.7
2	8.4	25.6	26.4	2.9	0.7
3	7.3	31.5	15.3	2.5	0.6

TABLE 2. SELECTED PHYSICAL AND CHEMICAL PROPERTIES OF 16 ALABAMA POND SEDIMENTS AND THE SIMAZINE HALF-LIVES IN LABORATORY SYSTEMS CONTAINING SEDIMENT AND DISTILLED WATER. CORRELATION COEFFICIENTS ARE FOR THE RELATIONSHIP BETWEEN THE SEDIMENT PROPERTY AND SIMAZINE HALF-LIFE.

Sediment number	pH	Cation Exchange capacity (meq/100 g)	Organic matter (%)	Clay (%)	Silt (%)	Sand (%)	Simazine half-life (days)
1	7.6	22.8	3.2	57	33	10	31.7
2	6.2	14.9	6.2	34	32	34	19.4
3	7.2	5.6	2.2	21	38	41	43.4
4	6.6	35.6	6.6	41	42	17	12.1
5	5.8	4.2	3.2	23	15	63	14.1
6	5.9	11.6	8.7	26	38	36	7.8
7	6.5	23.0	5.0	57	42	1	14.8
8	6.0	37.5	4.2	48	43	9	10.8
9	7.0	13.4	3.4	40	59	1	36.4
10	6.6	16.6	9.0	62	37	1	7.9
11	7.1	1.0	0.3	15	7	78	72.5
12	6.4	10.2	5.6	37	52	11	12.9
13	6.5	15.1	4.5	39	47	15	18.3
14	6.9	47.8	3.9	27	41	32	16.9
15	6.3	12.1	4.2	36	41	23	11.8
16	7.1	9.0	0.5	30	32	38	61.2
r-value	0.66[a]	−0.42	−0.82	−0.37	−0.45	0.53	

[a] Correlation coefficient (absolute value) of 0.50 at the 5 percent level and 0.62 at the 1 percent level required for significance.

of simazine from the water. Some fraction of the simazine is likely physically bound in the sediment and not lost from the system as a whole.

Simple linear correlation coefficients for the relationships between rate of simazine loss from water (as indicated by half-life) and certain sediment physical and chemical characteristics are presented in Table 2. Organic matter content and sediment pH were highly correlated ($P<0.01$) with the rate of simazine dissipation. Simazine was lost from the overlying water at a faster rate as organic matter content increased and pH decreased. Similar results have been reported in studies of *s*-triazine interactions with agricultural soils (11, 14). These studies have shown that soil organic matter is the soil property most highly related to herbicidal activity of soil applied chloro-*s*-triazines. The pH dependent adsorption of *s*-triazines has been attributed to the protonation of the weakly basic triazine molecules and adsorption of the organic cation to exchange sites on clays and acidic functional groups on organic colloids (13). Furthermore, microbial degradation of herbicides is often greater in soils of high organic content because of the increased general microbiological activity (1).

The results of the present study indicate that pond sediments are the major sink for simazine applied to ponds and the organic matter content and pH of the sediment influences the rate at which simazine is lost from the water. Studies in ponds are needed to test these trends under field conditions. Further evaluation of the factors affecting the persistence of phytotoxic simazine concentrations in ponds may allow more efficient use of the herbicide.

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