FATE OF TEBUTHIURON HERBICIDE IN A RECHARGE AREA OF GUARANY AQUIFER IN SUGARCANE FIELD IN BRAZIL

A.L. CERDEIRA[1*], M.D. DESOUZA[1], V.L. FERRACINI[1], S.C.N. QUEIROZ[1], D. BOLONHEZI[2], M.A.F. GOMEZ[1], O. BALDERRAMA[3], P. RAMPAZZO[3], R.H.C. QUEIROZ[4], M.B. MATALLO[5], [1]Embrapa, Meio-Ambiente, Jaguariuna - SP, Brazil. cerdeira@cnpma.embrapa.br; [2]Agronomic Institute of Campinas, APTA-Centro Leste, Ribeirao Preto - SP, Brazil; [3]Dow AgroSciences, Mogi Mirim Regulatory Laboratory, Mogi Mirim - SP, Brazil; [4]Pharmacy School of Sao Paulo University, USP, Ribeirao Preto - SP, Brazil; [5]Instituto Biologico, Campinas - SP, Brazil.

ABSTRACT: The region of Ribeirao Preto City located in Sao Paulo State, southeastern Brazil, is an important sugarcane, soybean and corn producing area. This region is also an important recharge area for groundwater of the Guarany aquifer, a water supply source of the city and region. The herbicide tebuthiuron (N-[5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl]-N,N'-dimethylurea) is regularly applied in the area. In order to understand the movement of tebuthiuron, laboratory studies were conducted at the Research Division of the Brazilian Department of Agriculture, Embrapa/Environment, Jaguariuna city, Sao Paulo State, Brazil. Tebuthiuron was applied at the recommended label rate with and without sugarcane coverage. Soil samples from Santa Rita do Passa Quatro county were collected at each 20 cm down to 120 cm and taken to the laboratory for determination of tebuthiuron. Tebuthiuron was measured at those depths mentioned before in ten intervals of time up to 300 days. Tebuthiuron half-lives varied from 69 days in sugarcane cropped area to 49 days in non-cropped area. After 180 days there were no measurable residues in the soil and tebuthiuron was not found below 40 cm depth in any time. This supports the lack of tebuthiuron residues found in groundwater in the monitoring program being performed in Ribeirao Preto. Tebuthiuron groundwater monitoring program is still on progress.

Key Words: Agriculture, Ground Water, Nonpoint Source Pollution, Solute Transport, Water Quality.

INTRODUCTION

The region of Ribeirao Preto City **(Figure 1)**, located in Sao Paulo State, southeastern Brazil, is an important sugarcane, soybean and corn producing area. This region is also an important recharge area for groundwater of the Guarany aquifer, a water supply source of the city and region. It has an intercontinental extension that comprises areas of eight Brazilian states, as well as significant portions of other South American countries like Argentina, Uruguay, and Paraguay, with a total area of approximately 1,200,000 Km^2.

Intensive cultivation in this area has required the constant use of pre-emergent herbicides and fertilizers. The risk of groundwater contamination by those chemicals, which are normally reapplied annually, has been a major concern. Due to the high permeability of some soils present in this region, the mobility of the herbicides and fertilizers applied, and being a recharge area, it is important to investigate the potential transport of applied herbicides to underlying aquifer.

Although it was generally accepted that pesticides would not leach to groundwater, recent studies indicate agrochemical leaching as an important source of agricultural non-point-source pollution (Smith et al. 2001), particularly in the last decade (Bouwer 1990). Other studies have indicated that some American aquifers were contaminated with both inorganic and organic compounds, some of which were pesticides (Williams et al. 1988).

The herbicide tebuthiuron is regularly applied in the watershed. Tebuthiuron (N-[5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl]-N,N'-dimethylurea) is a phenylurea herbicide used in sugar cane culture for pre and post-emergence control of weeds.

Figure 1. Map of South America showing the city of Ribeirao Preto, Brazil, where the watershed is located.

MATERIALS AND METHODS

In order to understand the movement of tebuthiuron in the area it was chosen two places with distinct soil characteristics to install the experiments with the herbicide. The study areas were located in the city of Ribeirão Preto and Santa Rita do Passa Quatro. The general climate of the area is tropical with dry winter savanna, an annual median temperature around 21°C and rainfall varying between 1300 and 1500 mm/year. Field research were conducted at the Alta Mogina Sao Paulo State Experiment Station, Ribeirao Preto, SP, and the Technical Agricultural School of the city of Santa Rita do Passa Quatro, Brazil. Laboratory studies were conducted at the Research Division of the Brazilian Department of Agriculture, Embrapa/Environment, Jaguariuna, SP, Dow AgroSciences, Mogi Mirim Regulatory Laboratory, Mogi Mirim, SP, and School of Pharmacy, São Paulo University, Ribeirão Preto Campus, SP, Brazil. The main soils are classified as Clayey Eutroferric Red Latosol (LVefb), Psamitic Distrofic Red Latosol (LVdq) and Quartzarenic Neosol (RQ), according to the Brazilian System of Soil Classification (EMBRAPA 1999).

Soil samples were collected and taken to the laboratory. Soil density (Mg/m^3), the relationship of soil mass to volume was measured using the Kopeck ring method described by Black (1965). Total porosity was measured based on the percentage of saturation in volume (Vomocil 1965). Microporosity was determined by the tension table method at a potential of 0.006 Mega Pascal (Mpa). After saturation and drying under tension, the samples were oven dried at 105°C to obtain the volume of micropores $\leq$ 0.05 mm. Macroporosity was obtained by the difference between micro and total porosity. Also evaluated were the % organic matter and physical properties of the soils for each depth (Klute 1986).

Water samples were collected from wells located inside the Espraiado watershed and from wells located at the edge in neighborhood by the road SP 332 **(Figure 2)**. The wells named as Recreio Internacional, São José, Palmares, Portinari, São Sebastião, and carry the name of the neighborhood, with exception of the control, DAERP Central, located in downtown. The well depths were around 100 m.

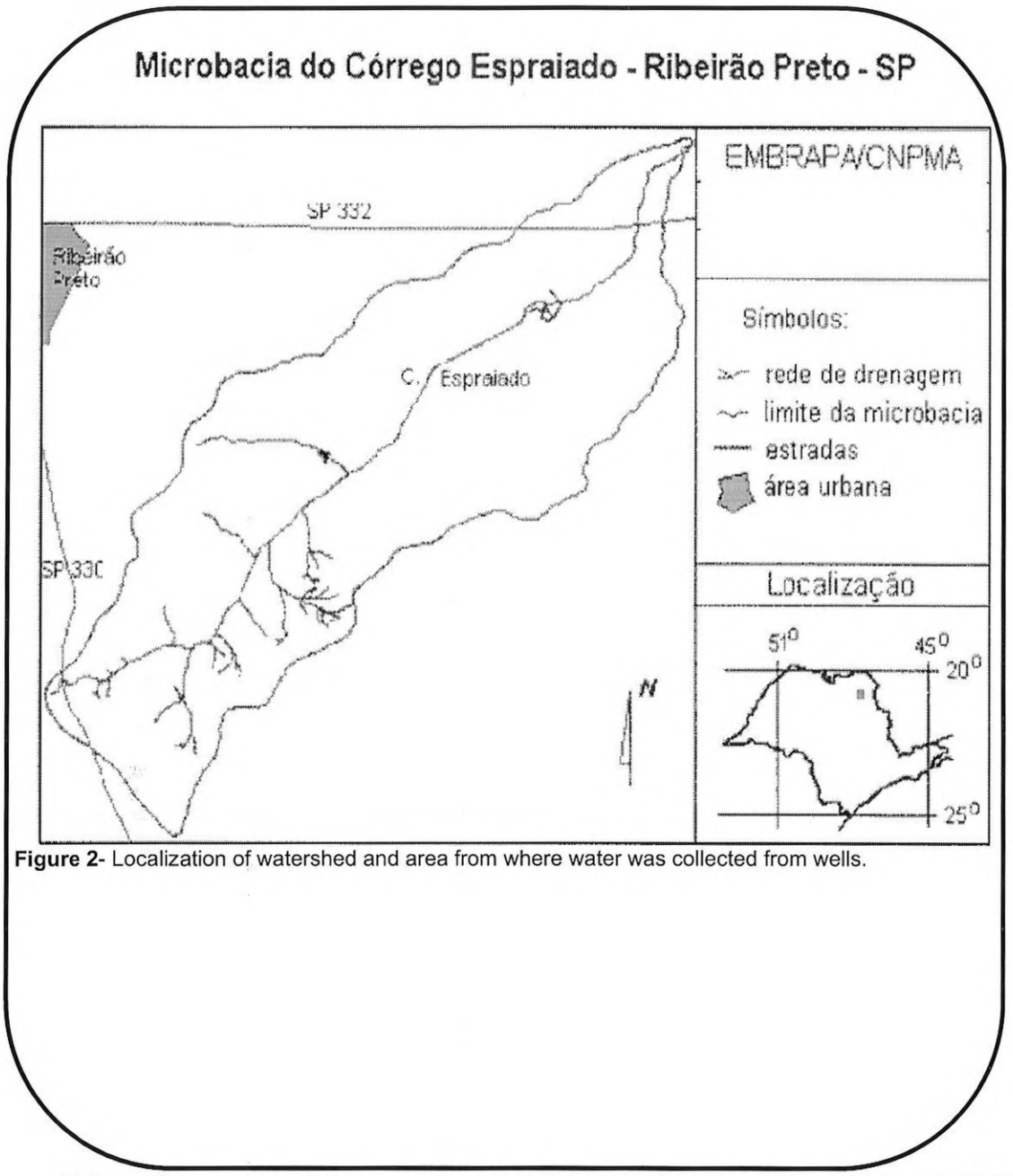

Figure 2- Localization of watershed and area from where water was collected from wells.

Soil samples were collected in trenches at 10 cm depths and their properties are shown in **Tables 1 and 2**.

Table 1. Soil micro, macro, total porosity, density, moisture (M, %), pH, Organic Carbon (OC, g/Kg), at various depths of Ribeirão Preto area.

Depth (cm)	Sand	Fine Sand	Silt	Clay	M (0.2 bar)	pH	OC	Macro	Micro	Total porosity	density
0-10	4.0	10.0	30.6	55.3	28,38	6.3	23.3	27,71	33,58	61,28	1,05
10-20	3.7	9.9	28.3	58.1	29,94	6.1	15.9	20,73	37,97	58,70	1,17
20-30	3.3	9.4	28.2	59.1	28,32	6.2	15.2	25,46	35,20	60,66	1,09
30-40	3.5	8.9	25.7	61.8	29,59	5.9	9.4	22,63	38,9	61,54	1,15

40-50									1		
	3.0	9.9	25.2	61.9	30,25	6.6	9.0	25,65	38,4 8	64,14	1,10
50-60	3.5	9.8	25.9	60.8	30,50	6.4	8.6	27,99	36,6 8	64,67	1,04
60-70	3.5	9.9	25.9	60.7	30,29	6.0	8.4	31,37	34,4 2	65,79	0,98
70-80	3.4	8.8	26.8	61.0	30,31	6.0	7.6	30,22	35,3 3	65,56	1,00
80-90	3.6	10.0	25.7	60.7	30,16	6.3	7.4	40,09	36,2 0	76,29	1,02
90-100	3.5	9.5	28.4	58.6	30,73	7.0	7.3	34,53	33,3 3	67,85	0,96

Table 2. Soil micro, macro, total porosity, density and moisture at various depths of in Santa Rita area.

Depths (cm)	Macro (%)	Micro (%)	Total Porosity (%)	Density (kg/dm^3)	Moisture 0.1 bar (%)
0-10	11,88	30,72	42,59	1,51	8,6
10-20	11,30	30,23	41,53	1,55	8,4
20-30	8,68	30,64	39,32	1,64	7,6
30-40	11,32	30,31	41,63	1,56	8,8
40-50	10,40	31,07	41,46	1,57	9,1
50-60	10,60	31,50	42,10	1,54	10,8
60-70	12,65	29,19	41,84	1,54	10,4
70-80	13,13	29,14	42,27	1,52	9,7
80-90	14,90	27,57	42,47	1,49	9,4
90-100	15,38	27,55	42,93	1,44	9,2
100-110	16,20	25,93	42,13	1,46	9,2
110-120	14,11	28,76	42,87	1,42	9,8

RESULTS AND DISCUSSION

Results from water samples collected at wells in groundwater samples have shown no residues of the herbicide.

The experiments conducted in Santa Rita area with sand soil have shown that tebuthiuron half-lives varied from 69 days in sugarcane cover area to 49 days where there was no crop cover. After 240 days there was no measurable residue in the soil and it was not found below 40 cm. depths **(Tables 3 and 4, and Figures 3 and 4).**

Table 3. Amount (mg/kg) of tebuthiuron found at various depths and time in Santa Rita with sugarcane cover.

Depth (CM)	**Control**	**0**[1]	**3**	**30**	**60**	**90**	**120**	**150**	**180**	**240**
0-20	ND[2]	0.33	0.115	0.12	0.080	0.075	0.08	0.025	0.035	ND
20-40	ND	ND	ND	0.02	0.02	ND	0.03	ND	0.02	ND
40-60	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
60-80	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
80-100	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
100-120	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

[1]DAA=Days after application. [2]ND= No detection.

Table 4. Amount (mg/kg) of tebuthiuron found at various depths and time in Santa Rita with no sugarcane cover.

Depth (CM)	**Control**	**0**[1]	**3**	**30**	**60**	**90**	**120**	**150**	**180**	**240**
0-20	ND[2]	0.41	0.39	0.08	0.12	0.07	0.06	0.025	0.025	ND
20-40	ND	0.15	0.02	ND	ND	ND	ND	ND	ND	ND
40-60	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
60-80	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
80-100	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
100-120	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

[1]DAA=Days after application. [2]ND= No detection.

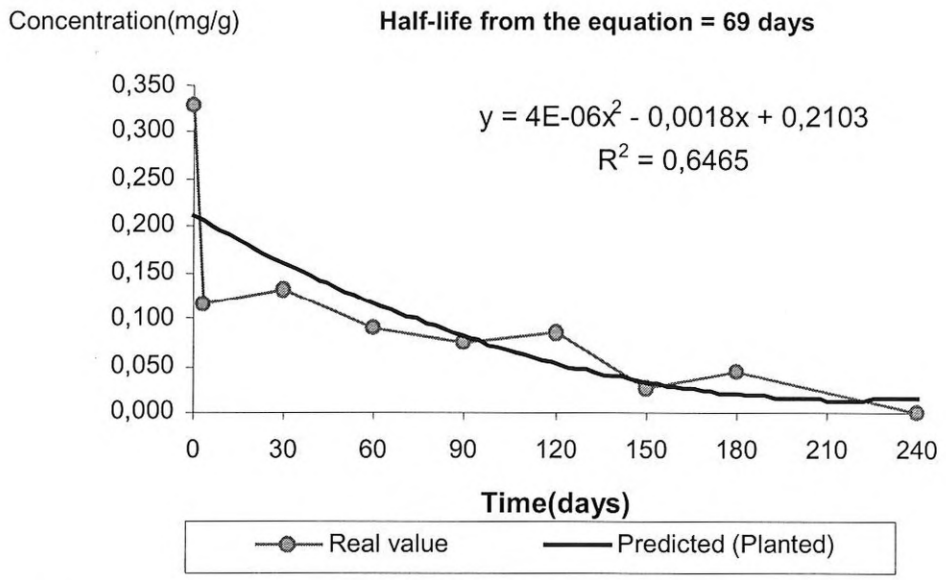

Figure 3. Tebuthiuron dissipation in sandy soil in Santa Rita with sugarcane cover.

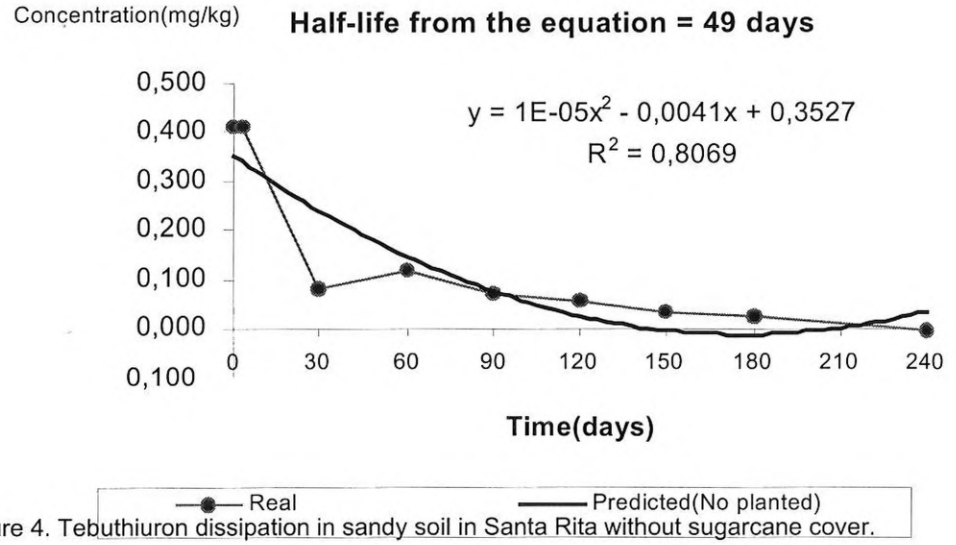

Figure 4. Tebuthiuron dissipation in sandy soil in Santa Rita without sugarcane cover.

REFERENCES

Black GR (1965) Bulk density. In: Black CA et al. (eds) Methods of Soil Analysis. Madison, American Society of Agronomy, pp 374-390

Bouwer H (1990) Agricultural chemicals and groundwater quality. J Soil Water Conserv 42:184-189

Klute A (1986) Physical and mineralogical methods. In: Black CA et al. (eds) Methods of Soil Analysis 2nd ed. Madison, American Society of Agronomy, pp 635-662

Smith S, Johnson RM, Pepperman AB (2001) Formulation and tillage effects on atrazine and alachlor in shallow groundwater in upland corn production Bull Environ Contam Toxicol 67:113-121

Vomocil JA (1965) Porosity. In: Black CA et al. (eds) Methods of Soil Analysis Madison, American Society of Agronomy, pp 299-314

Williams WM, Holden PW, Parsons DW, Lorber MN (1988) Pesticides in groundwater database. 1988 Interim Rpt. US Environmental Protection Agency, Washington DC 30p