U0U0U0U
atrazine

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
PESTICIDES AND
TOXIC
SUBSTANCES

MEMORANDUM

April 22, 1993

SUBJECT: Runoff Potentials for Triazine Alternatives

TO: Kathy Pearce
Review Manager
Special Review Branch
Special Review and Reregistration Division

FROM: R. David Jones, Ph.D. *R David Jones*
Agronomist
Surface Water Section
Environmental Fate and Ground Water Branch

THROUGH: Henry Nelson, Ph.D. *H Nelson*
Section Chief
Surface Water Section
Environmental Fate and Ground Water Branch

Henry Jacoby *Henry Jacoby 5/3/93*
Branch Chief
Environmental Fate And Ground Water Branch

The runoff potential of atrazine, cyanazine and simazine and their alternatives for use on corn was estimated using the PRZM model (Carsel *et al.*, 1985). Annual runoff values were generated from a simulated Iowa corn field for each triazine and alternative for the year 1948 to 1966, a total of nineteen years. The site was chosen to represent a reasonable worse case for pesticide runoff for corn agriculture. To make the comparisons, the second greatest year of the nineteen years was selected for each chemical and this value was divided by the annual application rate to generate the per cent of pesticide applied removed in runoff on an annual basis. This annual percent applied in lost runoff for each chemical was divided by the same value for atrazine to generate the relative runoff potential. These values are listed in the first column of Table 1. Chemicals with a relative runoff potentials greater than one are would probably run off greater amounts than atrazine. Conversely chemicals with a relative runoff potential less than 1 would probably run off in lesser amounts. Comparative analyses of this nature are using agricultural models such as PRZM is a reasonably robust use of the models. The Relative Runoff Index ranged in value from 0.22 for butylate to 1.39 for ametryn. Because of uncertainties in the input parameters, values between 0.75 and 1.33 are probably not significantly different than in runoff potential than atrazine.

Table 1. Runoff Potential of Triazine Herbicides and Their Alternatives On Corn.

Pesticide	Relative Runoff Potential*	Risk Index**
Alachlor (Lasso)	0.74	8.4
Ametryn (Evik)	1.39	7.0
Atrazine (Aatrex)	1.00	8.1
Butylate (Genate/Sutan)	0.22	5.9
Cyanazine (Bladex)	1.06	9.0
EPTC (Eradicane)	0.26	———
Linuron (Lorox)	1.27	———
Metolachlor (Dual)	1.26	6.9
Metribuzin (Sencor/Lexone)	1.42	5.6
Nicosulfuron (Accent)	1.18	———
Pendamethalin (Prowl)	0.51	———
Primisulfuron (Beacon)	1.24	———
Propachlor (Ramrod)	0.71	7.0
Simazine (Princep)	1.31	8.3

* Relative to atrazine
** Blank Entries in Risk Index column indicate that no drinking water health advisory has been set.

A risk index was also calculated by comparing the total amount of pesticide that ran off the field in the second worst year to the MCL (or other long-term health hazard index if no MCL has been set). These values can provide an estimate of the relative order of risk each chemical poses to human health based on the consumption of drinking water if each pesticide was applied to the same acreage of corn. This analysis shows that if equal amounts of each herbicide were applied to an area, cyanazine would pose the greatest health risk, alachlor, atrazine, and simazine are next greatest in risk and are fairly similar in value. Metribuzin would pose the least risk in this analysis even though it has the greatest runoff potential.

Purpose

The purpose of this effort is to estimate the runoff potential of atrazine, cyanazine, and simazine and their alternatives for use on corn. Additionally a risk index has been calculated which is an attempt to gauge the relative risks to human health from contamination of drinking water with these chemicals.

Model Used

The EEC's were calculated using two models: PRZM 1.0, dated January 28, 1992 to simulate the transport of the pesticide off the field. This version of PRZM 1.0 were part of the PIRANHA 3.0 shell, dated January 30, 1992.

Scenario

The scenario used was intended to simulate a 10 hectare corn field in Ringgold County, Iowa under conventional tillage with fall plowing. The scenario used was generated to create the worst case situation under which a farmer could legally farm and still be in compliance with the conservation compliance section of the Food Security Act of 1985. This scenario represents the 2nd year of corn in a meadow-meadow-corn-corn rotation which would be the year in the rotation that would be most prone to runoff and erosion. It should be remembered that this scenario could only occur once every four years on any particular field similar to the one simulated. The parameters used by PRZM to describe the climate and time frame are listed in Table 2. Parameters which are related to the crop being grown are in Table 3. Erosion parameters are in Table 4. The soil parameters used represented an Adair clay loam and are tabulated in Table 5. Pan evaporation, temperature and precipitation data were read from a meteorological file for MLRA M-108 which is provided with the PIRANHA shell.

Table 2. PRZM 1.0 Climate and Time Parameters for a Ringgold County, IA corn field under convention tillage.	
Parameter	Value
Starting Date	January 1, 1947
Ending Date	December 31, 1966
Pan Evaporation Factor (PFAC)	0.710
Snow Factor (SFAC)	0.200
Minimum Depth of Evaporation (ANETD)	15 cm
Area of Field (AFIELD)	10
Ave. Duration of Runoff Hydrograph (TR)	4.4 h

Table 3. PRZM 1.0 Crop Parameters for a Ringgold County, IA corn field under convention tillage.			
Parameter	Value		
Initial Crop (INCRP)	1		
Initial Surface Condition (ISCOND)	1		
Number of Different Crops (NDC)	1		
Max. interception storage of crop (CINTCP)	0.25 cm		
Maximum Active Root Depth (AMXDR)	90.0 cm		
Max Canopy Coverage (COVMAX)	100%		
Soil Surface After Harvest (ICNAH)	3 (residue)		
Index of crop growing in current year (INCROP)	1		
Number of Cropping Periods (NCPDS)	20		
Date of Crop Emergence (EMD, EMM, IRYEM)	May 21, each year		
Date of Crop Maturity (MAD, MAM, IYRMAT)	September 26, each year		
Date of Harvest (HAD, HAM, IYRHAR)	October 11, each year		
	Fallow	Cropped	Residue
SCS Runoff Curve Number (CN)	91	85	88
USLE C Factor (USLEC)	0.77	0.23	0.77

Table 4. PRZM 1.0 Erosion Parameters for a Ringgold County, IA corn field under convention tillage.	
Parameter	Value
USLE K Factor (USLEK)	0.43
USLE LS Factor (USLELS)	1.595
USLE P Factor (USLEP)	1

Table 5. PRZM 1.0 Soil Parameters for a Ringgold County, IA corn field under convention tillage.			
Parameter	Value		
Total Depth of Soil Core (CORED)	100		
Number of Soil Compartments (NCOM2)	50		
Initial Pesticide Level Index (ILP)	0		
Number of Soil Horizons (NHORIZ)	3		
	A Horizon	B Horizon	C Horizon
Horizon Thickness (THKNS)	44 cm	44 cm	12 cm
Soil Bulk Density (BD)	1.50	1.60	1.85
Dispersion Coefficient (DISP)	0 $cm^2 d^{-1}$	0 $cm^2 d^{-1}$	0 $cm^2 d^{-1}$
Initial Water Content (THETO)	0.355	0.388	0.307
Field Capacity (THEFC)	0.355	-.338	0.307
Wilting Point (THEWP)	0.185	0.208	0.167
Organic Carbon Content (OC)	2.32%	0.174%	0.116%

CHEMICAL PARAMETERS

A total of 23 chemicals were identified as being currently used as corn herbicides, considering all 2,4-D, bromoxynil, dicamba, and glyphosate derivatives as single compounds. Of these, the fifteen were analyzed to calculate relative runoff potentials. Of the rest, 2,4-D, bromoxynil, bentazon, dicamba, glyphosate, and paraquat were not analyzed as they are ionic under most environmental conditions and the chemistry algorithms of PRZM are not

5

validated for ions. Chloramben, oxyfluorfen, and trifluralin were not analyzed as they can only be applied to corn in certain states under restricted conditions. Pyridate degrades rapidly in the environment but it is not clear whether the degradates are of concern. Pyridate may be analyzed in the future when this issue is clarified.

Parameter Selection

Some general procedures were followed in selecting the fate data that were used in the modeling. All values with the exception of the cyanazine aerobic soil metabolism rate constant were taken from the EFGWB One-liner Database. The cyanazine aerobic soil metabolism constant was calculated from data provided by the registrant. If a group of values were available, the values used were of the greatest scientific acceptability, that is, fully acceptable studies were taken before supporting studies, which, in turn, were taken before any data from the scientific literature. If a number of values were available to generate the model parameter, the value which produce the most conservative (*i.e.* largest) runoff potential was chosen. If more than six values were available, a value which represented 95% of the distribution was chosen. If no data was available for a critical parameter, surrogate data were used either from some other related fate parameter, or from another chemical. If a surrogate value was used, the model parameter was always considered to be of poor quality.

Partition Coefficient. If partition coefficient data was unavailable, an alternative estimation method was used. These alternative estimation methods were, in order of preferability, comparative chromatographic analysis, selection of the least partition coefficient of other pyrethroid pesticides. Estimation using regression analysis from equations using solubility or octanol-water partition coefficients was deemed inappropriate for the pyrethroids as, in general, the pyrethroids are outside of the range of data needed to generate the equations.

A generic problem exists with the use of the soil-water partitioning data collected by the Agency in the models. This data is most often fitted to a Fruendlich isotherm:

$$C_a = K_f * (C_s)^{1/n}$$

where C_a is the concentration of the chemical absorbed to a the soil, C_s is the concentration of the chemical is solution, K_f is the Fruendlich partitioning constant, and 1/n is an exponential term which describes the curvature of the isotherm. This model often fits the data well and is the most appropriate model to use in many cases. Unfortunately, the fate and transport models available to the Agency are not as sophisticated and only have a linear (K_d) model for handling soil-water partitioning. In cases where only a K_f value was available, this parameter was used as a surrogate for K_d. The linear model and the Fruendlich model give similar results when the exponential parameter (1/n) is near a value of 1. However, when 1/n is not equal to one. the two models diverge significantly. Hence using Fruendlich K_f values as substitutes for K_d values may introduce a significant error in estimating the soil-water partitioning of a chemical.

PRZM Rate Constants. The aerobic soil metabolism rate constant was used to represent degradation in the A horizon. In the B horizon the anaerobic soil metabolism constant was used ~~if~~ it was available, otherwise the aerobic soil metabolism value was used.

Application Rate. Application rates were selected by using the most current label available and selecting maximum rate that could be applied to the field based on a pre-emergent application broadcast and unincorporated. The rate selected was the highest rate that was permitted on the label given the characteristics of the site and the application method. In some cases a pre-emergent application was not permitted by the label. If a pre-plant application was allowed, the application was made pre-plant and it was assumed it was made the same day as planting. If only post-emergent applications could be made the application was made in that manner. Only one application was made for each chemical. In some cases, the application rate was dependent on the soil organic matter content. For these, a organic matter content of 4%, corresponding to an organic carbon content of 2.32%, was used for the application rate determination.

Alachlor.

Alachlor is an acetanilide herbicide and is the active ingredient in Lasso®. In 1992, alachlor was the second greatest herbicide in mass applied in 1989 (Gianessi, 1992). Alachlor is primarily used for control of grasses and is not a true alternative for the triazines. It is often tank mixed with atrazine for broad spectrum weed control. Chemical specific parameters used in PRZM to simulate alachlor runoff are listed in Table 6.

Application Rate. Alachlor applied based on a fine soil texture (as defined on the label) and 3% or more organic matter. The label recommendation for these conditions is 2.5 to 3.25 quarts acre which corresponds to 3.6 kg-ai · ha^{-1}.

Soil Water Partition Coefficient. The K_d's for alachlor were calculated from a K_{oc} of 127 which represents the smallest K_{oc} value that can be calculated among the five measurements listed in the EFGWB One-liner data base.

Soil Degradation Rates. Since no anaerobic soil metabolism data was available, the aerobic soil metabolism rate constant was used for all three soil horizons. The aerobic soil metabolism half-life used was 21 d.

Table 6. PRZM 1.0 Input Parameters for Alachlor.				
Input Parameter	Soil Layer			Quality
Application Rate (TAPP)	3.643 kg • ha^{-1}			excellent
	A horizon	B horizon	C horizon	
Soil-Water Partition Coefficient (KD)	2.946 L • kg^{-1}	0.221 L • kg^{-1}	0.147 L • kg^{-1}	good
Soil Decay Rate (DKATE)	$3.3x10^{-2}$ d^{-1}	$3.3x10^{-2}$ d^{-1}	$3.3x10^{-2}$ d^{-1}	fair

Ametryn

Ametryn is a triazine herbicide and is the active ingredient in Evik® pesticide. Chemical specific parameters used in PRZM to simulate ametryn runoff are listed in Table 7.

Application Rate. Evik 80W contains 74% ametryn and 4% related compounds. For modeling purposes Evik 80W was treated as if it contained 80% ametryn. The application rate of Evik 80W to corn depends upon which of two regions of the United States (roughly divided into the southeastern United States and the rest of the country) the application is occurring and the weeds being treated. Evik 80W can only be applied to corn *after* it reaches 12 inches in height. To simulate this, Evik 80W was applied 4 weeks after emergence. The maximum application rate of Evik 80W in Iowa is 2.5 lb • $acre^{-1}$ or 2.242 kg-ai • ha^{-1}.

Soil-Water Partition Coefficient. A K_{oc} of 66.7 was used to generate the K_d's used in the simulations.

Soil Degradation Rates. The anaerobic soil metabolism rate was listed in the EFGWB One-liner Database as "stable", so a degradation rate of 0 d^{-1} was used in the simulations for the B and C horizons. The aerobic soil metabolism half-life used in the simulations was 84 d.

8

Table 7. PRZM 1.0 Input Parameters for Ametryn.				
Input Parameter	Soil Layer			Quality
Application Rate (TAPP)	2.242 kg • ha^{-1}			excellent
	A horizon	B horizon	C horizon	
Soil-Water Partition Coefficient (KD)	1.547 L • kg^{-1}	0.116 L • kg^{-1}	0.077 L • kg^{-1}	good
Soil Decay Rate (DKATE)	8.25x10^{-3} d^{-1}	0 d^{-1}	0 d^{-1}	fair

Atrazine

Atrazine is the active ingredient in Aatrex® herbicide and was the most applied herbicide in the US in 1989 (Gianessi, 1989). Atrazine is applied primarily for broadleaf control but has also has pesticidal activity against certain grasses. It is often mixed with other herbicides to obtain a broad spectrum of weed control. Chemical specific parameters used in PRZM to simulate atrazine runoff are listed in Table 8.

Application Rate. The rate selected was that for highly erodible land when less than 30% of the soil is covered with plant residue, 1.8 lb • acre^{-1}. Aatrex 90 contains 88.5% atrazine and 4.5% related compounds for a total of 90% active ingredient. Consequently, the application rate of active ingredient is 1.8 kg-ai • ha^{-1}.

Soil Water Partition Coefficient. A K_{oc} of 38 was used to generate the K_d's used in the simulations.

Soil Degradation Rates. The aerobic and anaerobic soil metabolism half-lives used were 21 d and 159 d respectively.

Table 8. PRZM 1.0 Input Parameters for Atrazine.				
Input Parameter	Soil Layer			Quality
Application Rate (TAPP)	1.816 kg • ha^{-1}			excellent
	Surface	A horizon	B horizon	
Soil-Water Partition Coefficient (KD)	0.516 L • kg^{-1}	0.039 L • kg^{-1}	0.026 L • kg^{-1}	good
Soil Decay Rate (DKATE)	3.3x10^{-1} d^{-1}	4.3x10^{-3} d^{-1}	4.3x10^{-3} d^{-1}	good

Butylate

Butylate is the active ingredient in Sutan®+ herbicide. Butylate is a carbamate pesticide primarily used for pre-plant control of grasses. Butylate was the eighth greatest in use in 1979 (Gianessi, 1992). Chemical specific parameters used in PRZM to simulate butylate runoff are listed in Table 9.

Application Rate. The maximum rate for Sutan® + 6.7E that is recommended for use for control of nutsedge, Texas panicum, and shattercane. This rate must be incorporated into the soil within 4 hours for efficacious weed control. The butylate was incorporated to a depth of 10 cm which is the minimum depth listed on the label. It was assumed that the application of butylate was made pre-plant and planting was made after application on the same day. The application rate listed for these weeds is 7⅓ pints per acre or 6.0 kg-ai · ha^{-1}. As with the other pesticides application was made the same day as planting. Note that on applications to corn

Soil Water Partition Coefficient. Values from three studies were listed in the EFGWB One-liner Data Base. One of these studies was on a gravelly sand and this data was considered to be unrepresentative of normal agricultural soil in the corn belt and not used for the analysis. The other two studies had a range of values listed and the lowest value from the two soils was chosen. Since organic carbon contents were not listed in the One-liner Database, it was not possible to calculate a K_{oc} so this K_d value was used for all three layers.

Soil Degradation Rates. The anaerobic soil metabolism rate constant is listed in the EFGWB One-Liner Database as ">90 days in Felton loamy (*sic*) soil". A value of 90 days was used for the degradation rate in the sub-surface horizons. An aerobic soil metabolism half-life of 56 d was used.

Table 9. PRZM 1.0 Input Parameters for Butylate.

Input Parameter	Value			Quality
Application Rate (TAPP)	6.884 kg · ha^{-1}			excellent
	Soil Layer			
	Surface	A horizon	B horizon	
Soil-Water Partition Coefficient (KD)	3.860 L · kg^{-1}	3.860 L · kg^{-1}	3.860 L · kg^{-1}	fair
Soil Decay Rate (DKATE)	1.24×10^{-2} d^{-1}	7.7×10^{-3} d^{-1}	7.7×10^{-3} d^{-1}	fair

Cyanazine

Cyanazine is a triazine herbicide and is the active ingredient in Bladex®. Cyanazine had the seventh greatest mass of use in 1979 (Gianessi, 1992). Cyanazine is primarily used to control broadleaf weeds but is effective against a different spectrum of weeds than atrazine. If atrazine were to be banned, cyanazine use would be expected to be the primary alternative (Bouzeher *et al.*, 1992; Keitt and Torla, 1992). Chemical specific parameters used in PRZM to simulate cyanazine are listed in Table 10.

Application Rate. The application rate for pre-emergent broadcast application of Bladex 4L on a clay loam soil with 4% organic matter is 4 lb per acre. This corresponds to 4.5 kg-ai $\cdot$ ha^{-1}.

Soil-Water Partition Coefficient. A K_{oc} of 32 was used to generate the K_d's used in the simulation.

Soil Degradation Rates. A fully acceptable aerobic soil metabolism study was available to the Agency for cyanazine that had a reported aerobic soil metabolism half-life of 17 d. A reanalysis of the data using a least squares linear regression on log transformed concentration data showed that a better estimate of the half life was 22.8 d with a 95% confidence interval of 20.8 to 25.1 d. This value was used in the simulation. The anaerobic half life was 108 d.

Table 10. PRZM 1.0 Input Parameters for Cyanazine.

Input Parameter	Value			Quality
Application Rate (TAPP)	4.483 kg $\cdot$ ha^{-1}			excellent
	Soil Layer			
	A horizon	B horizon	C horizon	
Soil-Water Partition Coefficient (KD)	0.736 L $\cdot$ kg^{-1}	0.055 L $\cdot$ kg^{-1}	0.036 L $\cdot$ kg^{-1}	fair
Soil Decay Rate (DKATE)	3.04×10^{-2} d^{-1}	6.4×10^{-3} d^{-1}	6.4×10^{-3} d^{-1}	fair

EPTC

EPTC is carbamate herbicide that is the active ingredient in Eradicane®. EPTC is primarily applied to corn pre-plant to control grassy weeds. EPTC is the herbicide with the fourth largest usage by mass in the United States. Chemical specific parameters used in PRZM to simulate EPTC runoff are listed in Table 11.

Application Rate. Eradicane 6.7-E is applied pre-plant and it is recommended that planting occur as soon as possible after application. Eradicane must be incorporated in 4 to 6 inches of soil. For this simulation, an incorporation depth of 4 inches and an application date on the day of planting was made. The maximum application rate of Eradicane 6.7-E is listed in the label as 7.33 pints • $acre^{-1}$ which corresponds to 6.9 kg-ai • ha^{-1}.

Soil Water Partition Coefficient. No organic carbon content was available in the EFGWB One-line- so the minimum K_d value was used for all three soil horizons.

Soil Degradation Rate. No data was available for the anaerobic soil metabolism rate so the aerobic soil metabolism rate was used for all three horizons. The aerobic soil metabolism half-life used was 47 d.

Table 11. PRZM 1.0 Input Parameters for EPTC.

Input Parameter	Value			Quality
Application Rate (TAPP)	6.881 kg • ha^{-1}			excellent
	Soil Layer			
	A horizon	B horizon	C horizon	
Soil-Water Partition Coefficient (KD)	0.38 L • kg^{-1}	0.38 L • kg^{-1}	0.38 L • kg^{-1}	fair
Soil Decay Rate (DKATE)	$1.48x10^{-2}$ d^{-1}	1.48^{-2} d^{-1}	$1.48x10^{-2}$ d^{-1}	poor

Linuron

Linuron is a substituted urea that is the active ingredient in Linex® and Lorox® herbicides. It is a post-emergent herbicide used to control both broadleaf and grassy weeds. Chemical specific parameters used in PRZM to simulate linuron runoff are listed in Table 12.

Application Rate. Lorox DF can be applied as a pre-emergent herbicide to corn in combination with alachlor, propachlor, or atrazine. The maximum application rate on fine-textured soils with greater than 3% organic matter is 3 lb • $acre^{-1}$ of formulated product or 1.7 kg • ha^{-1}.

Soil Water Partition Coefficients. The K_d's for linuron were calculated using a K_{oc} of 177.

Soil Degradation Rates. Since no anaerobic soil metabolism data was available, the aerobic soil metabolism rate constant was used for all three horizons. The aerobic soil metabolism half-life used was 91 d.

Table 12. PRZM 1.0 Input Parameters for Linuron.				
Input Parameter	Value			Quality
Application Rate (TAPP)	1.681 kg • ha^{-1}			excellent
	Soil Layer			
	A horizon	B horizon	C horizon	
Soil-Water Partition Coefficient (KD)	4.106 L • kg^{-1}	0.308 L • kg^{-1}	0.205 L • kg^{-1}	good
Soil Decay Rate (DKATE)	7.08x10^{-3} d^{-1}	7.08x10^{-3} d^{-1}	7.08x10^{-3} d^{-1}	poor

Metolachlor

Metolachlor is an acetamide herbicide that is the active ingredient in Dual®. Metolachlor is primarily used to control grassy weeds in corn. Metolachlor is the third most commonly used herbicide by mass in 1989 (Gianessi, 1992). Chemical specific parameters used in PRZM to simulate metolachlor runoff are listed in Table 13.

Application Rate. The rate of product recommended for use on fine textured soil with greater than 3% organic matter is 3 pints per acre which corresponds to 3.4 kg-ai • ha^{-1}.

Soil Water Partition Coefficient. The K_d's used in the simulations were generated using a K_{oc} of 125.

Soil Degradation Rates. Aerobic soil metabolism data submitted to the agency indicates that metolachlor is stable in the soil for 64 days. No anaerobic soil metabolism data is currently available. A degradation half-life of 90 d was listed in the SCS/ARS/CES database (Wauchope *et al.*, 1992) and this value was used for all three horizons.

Table 13. PRZM 1.0 Input Parameters for Metolachlor.				
Input Parameter	Value			Quality
Application Rate (TAPP)	3.363 kg • ha^{-1}			excellent
	Soil Layer			
	Surface	A horizon	B horizon	
Soil-Water Partition Coefficient (KD)	2.90 L • kg^{-1}	0.218 L • kg^{-1}	0.145 L • kg^{-1}	fair
Soil Decay Rate (DKATE)	7.7x10^{-3} d^{-1}	7.7x10^{-3} d^{-1}	7.7x10^{-3} d^{-1}	poor

13

Metribuzin

Metribuzin is the active ingredient in Lexone® and Sencor® pesticides. Chemical specific parameters used in PRZM to simulate metribuzin runoff are listed in Table 14.

Application Rate. Lexone and Sencor, formulations that contain metribuzin may be applied to field corn in conjunction with either alachlor or metolachlor and either atrazine or cyanazine to control certain broadleaf weeds. Metribuzin is applied at a rate of ¼ lb per acre or 0.28 kg • ha^{-1}.

Soil Water Partition Coefficient. The K_d's used in the simulations were generated using a K_{oc} of 13.1.

Soil Degradation Rates. The aerobic and anaerobic soil metabolism half-lives used were 106 and 112 d respectively.

Table 14. PRZM 1.0 Input Parameters for Metribuzin.				
Input Parameter	Value			Quality
Application Rate (TAPP)	0.28 kg • ha^{-1}			excellent
	Soil Layer			
	Surface	A horizon	B horizon	
Soil-Water Partition Coefficient (KD)	0.348 L • kg^{-1}	0.026 L • kg^{-1}	0.017 L • kg^{-1}	good
Soil Decay Rate (DKATE)	$6.5x10^{-3}$ d^{-1}	$6.2x10^{-3}$ d^{-1}	$6.2x10^{-3}$ d^{-1}	good

Nicosulfuron

Nicosulfuron is a sulfonylurea herbicide that is used as a post-emergent weed control in corn. It is the active ingredient in Accent® pesticide. Chemical specific parameters used in PRZM to simulate nicosulfuron runoff are listed in Table 15.

Application Rate. The application rate of Accent, the product which contains nicosulfuron, is applied at a maximum application rate of ⅔ oz per acre for a single application. This corresponds to 35 g-ai • ha^{-1}. Accent can only be applied post-emergence and was applied one week after emergence of the crop.

Soil Water Partition Coefficient. The K_d's used in the simulation were generated using a K_{oc} of 22.4.

Soil Degradation Rates. The aerobic and anaerobic soil metabolism half-lives used were 26 d and 63 d respectively.

Table 15. PRZM ~~1.0 Input~~ Parameters for Nicosulfuron.

Input Parameter	Value			Quality
Application Rate (TAPP)	0.035 kg • ha^{-1}			excellent
	Soil Layer			
	Surface	A horizon	B horizon	
Soil-Water Partition Coefficient (KD)	0.520 L • kg^{-1}	0.039 L • kg^{-1}	0.026 L • kg^{-1}	good
Soil Decay Rate (DKATE)	2.67×10^{-2} d^{-1}	1.10×10^{-2} d^{-1}	1.10×10^{-2} d^{-1}	good

Pendimethalin

Pendimethalin is the active ingredient in Prowl® herbicide. Pendimethalin had the ninth greatest herbicide use by mass in the US in 1989 (Gianessi, 1992). Chemical specific parameters used in PRZM to simulate pendimethalin runoff are listed in Table 16.

Application Rate. Pendimethalin was applied as a pre-emergent broadcast application using the rate for a fine-textured soil with 3% or more organic matter. This rate is 4 pints of product per acre or 2.242 kg-ai • ha^{-1}.

Soil Water Partition Coefficient. No soil water partition coefficient data has yet been accepted by the Agency. The value used, a K_{oc} of 5000, is from the SCS/ARS/CEC database (Wauchope *et al.*, 1992).

Soil Degradation Rates. The aerobic soil metabolism data submitted and accepted by the Agency indicates that the degradation half-life in soil was 1322 d. No appreciable degradation was measured in an anaerobic metabolism study. Yet the dissipation half-life from a terrestrial field dissipation half-life was found to be 44 d. Since pendamethalin does not appear to be prone to leaching some other, perhaps volatilization is removing it from the soil. In this case, the terrestrial field dissipation half-life was used to represent the degradation of the chemical in the soil as it appeared to be a better estimate of the dissipation of the compound by mechanisms other than runoff and leaching than the metabolism degradation studies.

Table 16. PRZM 1.0 Input Parameters for Pendimethalin.				
Input Parameter	Value			Quality
Application Rate (TAPP)	2.242 kg • ha^{-1}			
	Soil Layer			
	A horizon	B horizon	C horizon	
Soil-Water Partition Coefficient (KD)	116 L • kg^{-1}	8.7 L • kg^{-1}	5.8 L • kg^{-1}	poor
Soil Decay Rate (DKATE)	$1.54x10^{-2}$ d^{-1}	$1.54x10^{-2}$ d^{-1}	$1.54x10^{-2}$ d^{-1}	poor

Primisulfuron

Primisulfuron is a sulfonylurea herbicide used post-emergent weed control in corn. It is the active ingredient in Beacon®. Chemical specific parameters used in PRZM to simulate primisulfuron runoff are listed in Table 16.

Application Rate. The recommended rate of application for primisulfuron in the pesticide Beacon® is 0.76 oz • $acre^{-1}$ which corresponds to 53 g • ha^{-1}. Primisulfuron may only be applied post-emergent so application was made one week after emergence in the simulation.

Soil Water Partition Coefficient. No organic carbon content data was available for primisulfuron so a constant K_d of 0.02 was used for all horizons.

Soil Degradation Rates. The aerobic and anaerobic soil metabolism half-lives used were 63 and 89 d respectively.

Table 17. PRZM 1.0 Input Parameters for Primisulfuron.				
Input Parameter	Value			Quality
Application Rate (TAPP)	0.053 kg • ha^{-1}			excellent
	Soil Layer			
	Surface	A horizon	B horizon	
Soil-Water Partition Coefficient (KD)	0.02 L • kg^{-1}	0.02 L • kg^{-1}	0.02 L • kg^{-1}	fair
Soil Decay Rate (DKATE)	$1.1x10^{-2}$ d^{-1}	$7.8x10^{-3}$ d^{-1}	$7.8x10^{-3}$ d^{-1}	good

Propachlor

Propachlor, an acetanilide herbicide, is the active ingredient in Ramrod® pesticide. Chemical specific parameters used in PRZM to simulate propachlor runoff are listed in Table 18.

Application Rate. For application to corn, Ramrod® can be applied at rates from 5.5 to quarts $\cdot$ acre^{-1} on fine textured soils with greater than 3% organic matter. This corresponds to 6.7 kg $\cdot$ ha^{-1}.

Soil Water Partition Coefficient. No data on organic matter content was immediately available for the partition coefficient data submitted to the Agency. Consequently, the partition coefficient was not adjusted for organic matter and the same K_d was used for all three horizons.

Soil Degradation Rates. No data was available for anaerobic soil metabolism so the aerobic soil metabolism data was used for all three horizons. The aerobic soil metabolism half-life used was 7 d.

Table 18. PRZM 1.0 Input Parameters for Propachlor.

Input Parameter	Value			Quality
Application Rate (TAPP)	6.725 kg $\cdot$ ha^{-1}			excellent
	Soil Layer			
	Surface	A horizon	B horizon	
Soil-Water Partition Coefficient (KD)	0.56 L $\cdot$ kg^{-1}	0.56 L $\cdot$ kg^{-1}	0.56 L $\cdot$ kg^{-1}	fair
Soil Decay Rate (DKATE)	9.9×10^{-2} d^{-1}	9.9×10^{-2} d^{-1}	9.9×10^{-2} d^{-1}	fair

Simazine

Simazine is a triazine herbicide and the active ingredient in Princep®. About 30% of simazine use is on field corn (Keitt and Torla, 1992). Chemical specific parameters used in PRZM to simulate simazine runoff are listed in Table 19.

Application Rate. Simazine was applied at the rate recommended on the label of Princep® 80W. The recommended rate for fine textured soils is 3.75 lb $\cdot$ acre^{-1} which corresponds to 3.4 kg $\cdot$ ha^{-1}.

Soil Water Partition Coefficient. A K_{oc} of 103 was used to generate the K_d's used in the simulation.

Soil Degradation Rate. A degradation rate corresponding to 114 d was used for all three horizons as no anaerobic soil metabolism data was available.

Table 19. PRZM 1.0 Input Parameters for Simazine.				
Input Parameter	Value			Quality
Application Rate (TAPP)	3.363 kg • ha^{-1}			excellent
	Soil Layer			
	A horizon	B horizon	C horizon	
Soil-Water Partition Coefficient (KD)	2.390 L • kg^{-1}	0.179 L • kg^{-1}	0.119 L • kg^{-1}	good
Soil Decay Rate (DKATE)	6.1x10^{-3} d^{-1}	6.1x10^{-3} d^{-1}	6.1x10^{-3} d^{-1}	good

Procedure

The PRZM simulation was run for a period of nineteen years from 1948 to 1966 with application of the pesticide every year at planting. It should be remembered that every year has been modeled as if it were the worst year in a four year rotation. For calculating the relative runoff potential, the second greatest annual pesticide runoff was selected. The second greatest year was used rather the greatest year as it would be expected to be somewhat more stable value numerically. This value was divided by the application rate to give the per cent of applied, PApp, that ran off the field. PApp for each pesticide was then divided by PApp for atrazine to generate the relative runoff potential.

To calculate the Risk Index for risk to human health from contamination of drinking water, the following formula was used:

$$RI = \log\left(\frac{RU(kg \cdot ha^{-1}) * 1.0x10^{9}(\mu g \cdot kg^{-1})}{MCL(\mu g \cdot L^{-1})}\right)$$

where RI is the risk index, the RU is the runoff in kg • L^{-1}, MCL is the maximum contaminant level in μg • L^{-1} and the 1.0x10^{-1} is a conversion factor from kg to μg. For some chemicals no MCL has been set, in these cases, if the maximum contaminant level goal (MCLG) was available it was used. If this value was not available, the lifetime health advisory was used. If this was not available, a Risk Index was not calculated.

Results

Both the relative runoff potential and risk index for each herbicide analyzed are listed in Table 1. Chemicals with a relative runoff potentials greater than one are would probably run off greater amounts than atrazine. Conversely chemicals with a relative runoff potential less than 1 would probably run off in lesser amounts. The relative runoff potential values ranged from 0.22 for butylate to 1.42 for metribuzin. Because of uncertainties in the input parameters, values between 0.75 and 1.33 are probably not significantly different than in runoff potential than atrazine. By this criterion, five chemicals, alachlor, butylate, EPTC, pendamethalin, are significantly less likely to run off and two, ametryn, metribuzin are significantly more likely. However, alachlor, and propachlor are just outside the range and 0.74 and 0.71. This general similarity of the corn herbicides may be indicative of efforts by pesticide manufacturers to design herbicides with these properties so that they persist long enough to be effective, but not so long as to interfere with rotational crops.

A risk index was also calculated by comparing the total amount of pesticide that ran off the field in the second worst year to the MCL (or other long-term health hazard index if no MCL has been set). These values can provide an estimate of the relative order of risk each chemical poses to human health based on the consumption of drinking water if each pesticide was applied to the same acreage of corn. This analysis shows that if equal amounts of each herbicide were applied to an area, cyanazine would pose the greatest health risk, alachlor, atrazine, and simazine are next greatest in risk and are fairly similar in value. Metribuzin would pose the least risk in this analysis, even though it has the greatest runoff potential. The factors which appear to most greatly influence the potential risk of cyanazine are application rate and the hazard value, which for cyanazine is an MCLG of 1 $\mu g \cdot L^{-1}$.

Limitations of This Analysis.

This analysis was done to present a rough guide to the relative runoff potentials and risks of the corn herbicides. The primary factor limiting the accuracy of the analysis are the quality of the fate parameters used (*i.e.* garbage in, garbage out). A conscious decision was made to only use values as listed in the EFGWB One-liner Database as reviewing the original studies can be quite time consuming. Experience has shown that a more complete analysis of the original studies submitted to the Agency can dramatically improve the quality of the parameters for use in modeling environmental fate and transport. Using the maximum label rates also limits the accuracy of the analysis; use of typical rates would be more appropriate for this type of analysis.

The analysis could also be improved by using knowledge of the actual distributions of the input parameters to develop quantitative confidence intervals to replace the qualitative confidence interval that was used in the analysis. Changing the model used from PRZM to PRZM II also may improve the analysis, particularly for pesticides like butylate that have a tendency to volatilize as PRZM II has routines to handle this process explicitly.

LITERATURE CITATIONS

Bouzaher, A. and A. Manale. 1992. *CEEPES Atrazine Project: Research memos 1-5.* Performed by Iowa State University, Ames, IA, for the Office of Planning and Policy Evaluation, U.S. Environmental Protection Agency, Washington, D.C.

Carsel, R. F., C. N. Smith, L. A. Mulkey, J. D. Dean, and P. Jowise. 1984. *Users Manual for the Pesticide Root Zone Model (PRZM), Release 1.* EPA-600/3-84-109. Environmental Research Laboratory, U.S. Environmental Protection Agency, Athens, GA and Anderson Nichols, Inc., Palo Alto, CA.

Gianessi, L. P. 1992. *U.S. Pesticide Use Trends: 1966-1989.* Resources for the Future.

Keitt, G. and R. Torla. 1992. *Transmission of Current Usage and Benefits Information for Atrazine, Cyanazine and Simazine.* OPP internal memo from Allen L. Jennings, Director, BEAD to Daniel Barolo, Director, SRRD, dated June 8, 1992.

Wauchope, R.D. , T.M. Buttler, A.G. Hornsby, P.W.M. Augustijn-Beckers, and J.P. Burt. 1992. The SCS/ARS/CES Pesticide Database for Environmental Decision-Making. *Reviews of Environmental Toxicology, Vol. 123.* p 115.

cc: Betsy Grim
Andy Manale
reading file

DP BARCODE: D185563

CASE: 838836	DATA PACKAGE RECORD	DATE: 04/22/93
SUBMISSION: S430949	BEAN SHEET	Page 1 of 1

* * * CASE/SUBMISSION INFORMATION * * *

CASE TYPE: SPECIAL REVIEW   ACTION: 860 SRB OTHER
CHEMICALS: 080803 Atrazine (ANSI)   100.00 %

ID#: 080803
COMPANY:
PRODUCT MANAGER: 62   ROOM:
PM TEAM REVIEWER: KATHLEEN PEARCE   703-308-8016   ROOM: CS1 1N5
RECEIVED DATE: 12/10/92   DUE OUT DATE: 01/05/93

* * * DATA PACKAGE INFORMATION * * *

DP BARCODE: 185563   EXPEDITE: N   DATE SENT: 12/10/92   DATE RET.: / /
CHEMICAL: 080803 Atrazine (ANSI)
DP TYPE: 001 Submission Related Data Package
ADMIN DUE DATE: 01/05/93   CSF: LABEL:

ASSIGNED TO	DATE IN	DATE OUT
DIV : EFED	12/10/92	/ /
BRAN: EFGB	12/11/92	/ /
SECT: SWS	12/13/92	/ /
REVR : DJONES	12/14/92	04/22/93
CONTR:	/ /	/ /

* * * DATA REVIEW INSTRUCTIONS * * *

TO: David Jones, EFGWB: Please provide a table showing run-off and leaching potential of atraz simaz, cyanazine and their alternatives for briefings on potential Special Review of the three triazines. Thank you. kp/srrd/srb

* * * ADDITIONAL DATA PACKAGES FOR THIS SUBMISSION * * *

DP BC	BRANCH/SECTION	DATE OUT	DUE BACK	INS	CSF	LABEL