Residential Transfer Coefficients: A Review

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Introduction

Transfer coefficients link the measured surface pesticide residue to potential dermal exposure. The concept of transfer coefficients was originally conceived to aid estimation of occupational exposures to pesticides in agricultural settings. The approach has more recently been adapted to assessment of children's exposures to consumer products in residential settings, an area of increasing regulatory scrutiny. A review of the literature found 11 articles by nine authors that provide the necessary data to calculate a residential transfer coefficient. The review was completed in an attempt to find relationships between transfer coefficients based on the methodology of each study.

What is a Transfer Coefficient?

A transfer coefficient (TC) is an estimate of the surface area in which all the dislodgeable residue has been removed in a given time with units of cm^2/hr. It is calculated using three parameters: transferred residue (TR) to the person, exposure time (ET), and dislodgeable residue (DR) in the following equation.

Equation 1:

$$TC\ (cm^2/hr) = \frac{TR\ (\mu g)/ET\ (hr)}{DR\ (\mu g/cm^2)}$$

Transfer coefficients are used in concert with surface residue data and an estimate of dermal availability to predict the absorbed dose experienced by people coming into contact with chemically treated surfaces. To accurately assess an individual's absorbed dose it is important to calculate a transfer coefficient that embodies the chemical agent, surface material, and activity level and age of the subject.

Residue Collection Methods

Current studies examining transfer coefficients vary greatly in their individual methodologies. Different transfer coefficients result depending on the methods used to determine transferred and dislodgeable residues.

Transferred Residues
- Biomonitoring, Dosimetry

Dislodgeable Residues
- CDFA Roller, PUF Roller, Dow Sled, Surface Wipe, Carpet Extraction, Deposition Coupons (Aluminum Foil, Gauze)

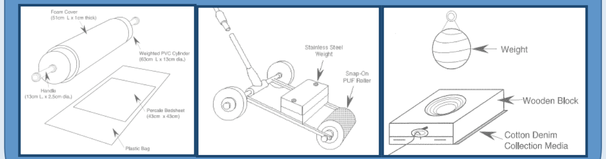

Fig. 1 Dislodgeable Residue Collection Tools (L to R): CDFA Roller, PUF Roller, Dow Sled. (US EPA Scientific Advisory Panel, 1998)

Variability in Transfer Coefficients

Since transfer coefficients are dependent on the amount of residue transferred to the person given the proportion of the total residue that is dislodgeable, the method used to determine dislodgeable residues is important. These methods vary in their aggressiveness, or ability to dislodge accessible residue, ranging from minimal to virtually complete recovery. Other variables including chemical agent, surface material, method of application, age of subjects, and type of activity completed all impact the resulting transfer coefficient. With such wide-ranging methodological variability, it is difficult to determine a single transfer coefficient value that is representative of actual environmental conditions. Therefore, results generally cannot be directly compared across studies.

Fig. 2 Children may be at an increased risk due to greater exposure to treated surfaces and child-specific activities.

Table 1: Transfer Coefficients Calculated Across Studies Given Transferred and Dislodgeable Residue Collection Methods and Chemical Agent

TR Collection Method	DR Collection Method	Chemical	Study	TC (cm^2/hr)
Biomonitoring	Carpet Extraction	cyfluthrin	Williams 2003	480
	CDFA Roller	chlorpyrifos	Krieger 2000	4480
		chlorpyrifos	Williams 2004	16300
		cyfluthrin	Williams 2003	26300
	Dow Sled	chlorpyrifos	Vacarro Unpublished	9420
	Foil Coupon	chlorpyrifos	Krieger 2000	330
		chlorpyrifos	Vacarro Unpublished	47
	Gauze Coupon	chlorpyrifos	Williams 2004	2360
		chlorpyrifos	Vacarro Unpublished	56
Dosimeter	Carpet Extraction	chlorpyrifos	EPA 1998	5850
		cyfluthrin	Williams 2003	100
	CDFA Roller	chlorpyrifos	Krieger 2000	153000
		chlorpyrifos	Ross 1991	198000
		cyfluthrin	Williams 2003	5550
		d-trans-allethrin	Ross 1991	137000
		propetamphos	Formoli 1996	43100
	Foil Coupon	chlorpyrifos	Krieger 2000	11400
		chlorpyrifos	Ross 1990	4600
		d-trans allethrin	Ross 1990	3660
	Gauze Coupon	chlorpyrifos	Ross 1990	2490
		d-trans allethrin	Ross 1990	3360
	Hard Surface Wipe	chlorpyrifos	Bradman 2007	1580
		chlorpyrifos	Tulve 2008	9170
		chlorthal-dimethyl	Bradman 2007	1990
		cis-permethrin	Bradman 2007	97500
		cis-permethrin	Tulve 2008	4810
		cypermethrin	Tulve 2008	320
		diazinon	Bradman 2007	13800
		esfenvalerate	Cohen Hubal 2006	1290
		piperonyl butoxide	Tulve 2008	564
		trans-permethrin	Bradman 2007	45700
		trans-permethrin	Tulve 2008	700

Transfer coefficients across studies range by a factor of 4200, illustrating the magnitude of variability depending on experimental methods. However, the spread of transfer coefficient data does not render it valueless. Calculating transfer coefficients using data from observational studies will provide insight into what current experimental methods best represent real-life dermal exposure.

US EPA CTEPP Case Study

This observational study examined the aggregate exposure to permethrin of 127 children ages 2-5 via ingestion (dietary and soil), inhalation, and dermal routes. Using a mass-balance approach, the predicted urinary biomarker output only accounted for approximately 60% of the observed urinary output. This urinary shortfall may be due to two questionable assumptions in assessing the dermal route of exposure:

1. Hand Wipe- used to measure transferred residue, but fails to account for what's already been absorbed or washed off by other means prior to sampling
2. 2% Absorption Factor- determined from scabies cream treatments which differ substantially from actual exposure conditions

Simple calculations demonstrate that dermal exposure can explain the apparent missing dose using plausible estimates of a residential transfer coefficient and measured surface pesticide loads.

Equation 2:

$$TC = \frac{[UC*UO*BW*PU*(MWP/MW3)]/ET}{PR\ or\ SW}$$

Table 2: Parameters Used to Calculate Transfer Coefficients

Factor	Symbol	Unit	Value [1]	TC (cm^2/hr)
Urine Concentration	UC	ng/mL	0.39	
Urine Output	UO	mL/kg	22	
Body Weight [2]	BW	kg	17.4	
Molecular Weight of Permethrin	MWP	g	391.3	
Molecular Weight of 3-PBA	MW3	g	214.2	
Percent unaccounted for in urine	PU	%	0.4	
Exposure time	ET	hr	12	
PUF Roller [3]	PR	ng/cm^2	0.0035	2700
Hard Floor Surface Wipe	SW	ng/cm^2	0.01	900

1-GM used in raw data; 2-Exposure Factors Handbook for 4 year-old child; 3-Referred to as Transferable Residues in study

Transfer coefficients calculated from this study are comparable to those determined using a variety of experimental methods. This provides further evidence to suggest that the dermal route of exposure could explain the observed urinary shortfall.

Next Steps

- Apply transfer coefficient methods to additional studies that use a mass-balance approach and different chemical agents to solidify dermal route evidence
- Assess realistic value of experimental methods based on results of case study examinations

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References

Please refer to handouts for a complete list of references.