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An update of the Human Toxicity Potential with special consideration of conventional air pollutants

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Abstract

We present updated values for the Human Toxicity Potential (HTP) of 349 pollutants. The HTP is a characterization method used to weight emissions, such as those listed in life-cycle inventories and toxic release inventories. HTP is a screening-level risk indicator that accounts for both toxicity and the potential to result in exposure, but that does not account for regional differences or variations in population density. This paper introduces new calculations for conventional air pollutants, which also account for the oxidation products of SO2 and NOx, which are more dangerous than the primary pollutants. For the first time, we take into account the scale of mixing in the atmosphere. Calculations are presented for emissions to air, surface water, as well as to agricultural and non-agricultural soil at two different soil depths. This update also reflects changes in the underlying toxicity data. Because sulfur dioxide and nitrogen oxides are ubiquitous and emitted in large amounts, this update has a significant impact on life cycle assessment results.[1]

Key words: Life cycle assessment (LCA), toxic release inventory (TRI), risk assessment, environmental indicators, air pollution, multimedia fate and exposure models

[1] This paper has been submitted to the *Journal of Industrial Ecology* in March 2003. Due to time constraints, we were not able to follow up the review and chose to publish this as a working paper instead.

Introduction

The HTP is an indicator used to compare the relative importance of toxic emission in situations where a site-specific risk assessment would be too expensive or data on the release sites is not always available (Hertwich et al. 2001; Hertwich et al. 1997). It can also be used as a screening-level assessment to identify those releases for which a more detailed risk assessment is recommended (Hertwich et al. 2002). The HTP is used by the Scorecard web site to rank pollution releases contained in the Toxics Release Inventory (TRI) and to recommend priorities of action.[2] It has been incorporated into TRACI, the life-cycle impact assessment software of the US Environmental Protection Agency (Bare 2002; Bare et al. 2003), and into BEES, the ecodesign software for architects and building engineers provided by the US National Institute of Standards and Technology (NIST 2000). We developed the HTP based on a proposal by Guinée and Heijungs (1993), but distinguish between cancer and noncancer health effects, following the US tradition of risk assessment. The HTP values calculated by Huijbregts and colleagues (2000), in contrast, combine those two endpoints and calculate only a single indicator.

In this paper, we present a four-fold update of the Human Toxicity Potential (HTP). (1) New calculations for a range of inorganic, non-persistent air pollutants, often referred to as conventional pollutants (in the US: 'criteria' air pollutants). These calculations are based only on exposure to airborne pollutants and do not include exposure through routes other than inhalation. We take into account the oxidation products of SO2 and NO2. (2) The consideration of two new release routes: emissions to surface soil or root-zone soil. (3) The pollutant-specific atmospheric mixing height (scale height) is for the first time taken into account in calculating the expected air concentrations. It turns out that this can have a substantial effect on the expected inhalation exposure. (4) An update of the underlying data, mostly on the toxicity side.

The calculation methods, choices, uncertainty and application of the HTP have been documented extensively in the scientific literature, and we refer the reader to this documentation for further detail (Hertwich et al. 2001; Hertwich et al. 2000; McKone and Hertwich 2001). The purpose of this paper is to document the update of the Human Toxicity Potential.

The calculation of the Human Toxicity Potential is based on CalTOX, a generic fate and exposure model which determines the distribution of a chemical in a model environment and accounts for a number of exposure routes, including inhalation of gases and particles, ingestion of produce, fish, and meat, and dermal contact with water and soil (Maddalena et al. 1995; McKone 1993). The advantage of such a 'multimedia' model is that it accounts for the transfer of pollutants among different environmental compartments or 'media' (air, water, soil). It thus does not treat deposition of a pollutant onto plants as a removal of the pollutant from the environment, as air-modeling based risk assessments implicitly do. Instead, it traces the fate of the pollutants on soil and vegetation and takes this as the starting point for calculating human exposure. A limitation is that multimedia models do not contain an explicit reaction chemistry. Transformation products are not accounted for in the HTP, even if the modeling of transformation products is possible using a multimedia modeling approach

[2] http://www.scorecard.org/ranking/

(Fenner et al. 2000). In addition, the model is not spatially explicit; the atmosphere is represented by a single box.
For a number of important inorganic air pollutants, transport to other media is not important, at least for human health. For sulfur dioxide and nitrogen oxides, however, the oxidation and subsequent particulate or aerosol formation substantially increases the toxicity. This has not yet been accounted for in HTP. We present a simple model to include these effects based on average deposition and oxidation rates.[3] A simple residence-time model is also applied to ozone, carbon monoxide, and several acids. For many of these pollutants, detailed models of chemical fate exist. These models show that the residence time, reaction rates, and gas-particle partitioning depend on temperature, humidity, concentrations of potential reaction partners etc. Atmospheric concentrations are therefore dependent on scenario-specific factors that cannot be included in screening-level or generic assessments as they are required for LCA.

The modeling of pollutant fate in soil is the most sophisticated in CalTOX, compared to similar models, because CalTOX was developed for assessing the risks from hazardous waste sites and contaminated ground. We still did not offer HTP values for emissions to soil (Hertwich et al. 2001), because the exposure calculations in CalTOX are very scenario specific. Exposure also often depends on the role of plants in transporting chemicals, a role that is difficult to model. After finding that the modeling of exposure through food and feed plants in traditional exposure analysis was insufficient for about 25% of the chemicals in the TRI (Hertwich et al. 2000), we had proposed a new approach to modeling the concentration in plants (Hertwich et al. 2001). We wanted to wait for this approach to be tested and reviewed. We realize, however, that in LCA there is a need for such HTP values for a number of applications, including pesticides and the use of sewage sludge as fertilizers for agricultural and non-agricultural soil. We now modified CalTOX through the introduction of a second soil column. Each soil column consists of ground-surface soil, root-zone soil and vadose zone soil. One soil column is used for agriculture, the second is not. So we could, in principle, calculate six different HTP values for soil, but we limit ourselves to four, because we judge emissions to vadose zone soil to be not of importance.

The HTP values depend on the chemical and toxicological properties of chemicals. The availability of data to describe relevant parameters is limited, and data is uncertain both because of a limited number of measurements and because of interpretation issues. Problems of interpretation are most apparent with toxicity data, because tests are expensive, measurement uncertainties exist especially in epidemiological studies, and the extrapolation of toxicity measurements from highly dosed animals to humans receiving low doses involves a number of assumptions, or leaps of faith. Regulatory agencies, such as the International Agency for Research on Cancer (IARC) and US EPA produce toxicity data and store it in publicly accessible or confidential databases, because this data is used for regulating chemicals. Data regarding the physical-chemical properties of chemicals, the data that is used to determine the fate of a chemical in the environment, unfortunately receives less attention. There are no databases available that are continuously updated, maintained, and authoritative. This is an major gap because, taken together, data on the persistence, vapor pressure, solubility, and bioaccumulation of chemicals is as important in determining the risks posed by chemicals as is their toxicity.

[3] While this model goes back a long way in air pollution assessment and is not nearly as sophisticated as today's air pollution model, we argue that it is sufficient for the purpose at hand.

Methods

Conventional air pollutants

For non-carcinogenic effects, the HTP builds on the hazard-index approach of risk assessment

$$\mathrm{HI} = \frac{\text{Potential dose}}{\text{Safe dose}}$$

In HTP, the potential dose is the dose resulting from a 1 kg/d emissions rate into an area of the size of the contiguous United States (A=8.0 e+12 m^2). For the air pollutants, we use a modified equation,

$$\mathrm{HI} = \frac{\text{Potential concentration}}{\text{Safe concentration}}$$

where we use as safe concentration the reference concentration (RfC) or National Ambient Air Quality Standards (NAAQS) published by US EPA. The potential concentration is the outdoor concentration resulting from a 1 kg/d emissions rate into an area of the size of the contiguous United States and a height h=700 m. The HI is then normalized by the hazard index of air emissions toluene (1.87 e-9) to express HTP in toluene-equivalents.

HTP values to date do not include the fate and effect of transformation products, as data on the generation and chemicals fate is not available for most chemicals (Hertwich et al. 2001). This is an important shortcoming because transformation products can be more important in terms of their environmental impact than the original pollutants. For NO2 and SO2 presented in this assessment, we for the first time include the oxidation products of those to chemicals. We simply add the hazard indexes for the parent compound and the progeny. We do not take into account NO2's contribution to photochemical smog, and treat NOx as NO2.

Data on deposition speeds (settling velocities) v or atmospheric residence times τ were obtained from the literature. The average concentration in the atmosphere was calculated

$$\mathrm{C} = \frac{\mathrm{Q}}{\mathrm{v\,A}} \qquad \text{or} \qquad \mathrm{C} = \frac{\mathrm{Q}\tau}{\mathrm{h\,A}}$$

For SO2 and NOx, the oxidation of the chemical and the formation of aerosols was also considered, as these secondary products are known to be more hazardous than the primary gases. We follow the simplified "unit world" model presented by Spadaro and Rabl (Spadaro 1999; Spadaro and Rabl 1999). In addition, we present a sensitivity analysis based on persistence and transformation data from the literature. For nitric acid and ammonia, the partitioning into particles is also considered.

Table 1 lists the RfC (NAAQS) and residence times for the different chemical species.

The challenge in this work was to identify the correct residence times or deposition rate for particulates. Spadaro (1999) uses a residence time of 29h for PM10. Seinfeld and Pandis (1998, p 467) provide a figure for the settling velocity of particles as a function of particle diameter which would suggest significantly higher residence times for both PM10 and

especially PM2.5. This does not include the effect of wet deposition, however. For fine particles, Seinfeld and Pandis state an atmospheric lifetime of "days-weeks," we have chosen exactly 1 week for PM2.5 (Seinfeld and Pandis 1998, p 443). For PM10 we use 2 days, as given in CalTOX (McKone 1993). For sulfates, they use a deposition lifetime of 80 h (Seinfeld and Pandis 1998, p 66), which is a combination of wet and dry deposition rates. Note that sulfate can exist as both as dry particle and wet aerosol. Its dry deposition speed if fairly slow, so it can have much larger residence times in dry air. In humid air and clouds, it is rapidly converted to a wet aerosol, which is more readily deposited (Venkatram et al. 1982). A graphic display of the atmospheric residence time suggests 20 d (Seinfeld and Pandis 1998, p 41). Similar problems exist with respect to nitrate and ammonia. We use an atmospheric residence time of 80 h for all secondary particles.

For SO2, we use a deposition lifetime of 37.5 h and an oxidation rate of 1.25% per hour (Seinfeld and Pandis 1998, p 66). For NOx, we use a dry deposition rate of 3.6 m/h for NO2 and 144 m/h for HNO3 (g) (Seinfeld and Pandis 1998, p 969). We assume that half of the HNO3 is deposited as dry deposition, and the rest in converted to particulate nitrate with a lifetime of 80h. In reality, the absorption of HNO3 by aerosols is a reversible process and strongly depends on the acidity of the aerosol, i.e. the concentration of sulfate, ammonia, and other ionic species (Na, Cl, etc.). Our combined HNO3+nitrate lifetime is 42 h, in agreement with the studies reported by Schwartz (1989). For sulfate, the NAAQS for PM2.5 (15 ug/m3) was used, for nitrate and HNO3, the RfD for HNO3 (30 ug/m3) was used. A different treatment of sulfate and nitrate is justified because sulfate is commonly associated with smaller particles than nitrate (Capaldo et al. 2000).

Table 1: Safe concentration, residence time, and Human Toxicity Potential (toluene equivalents) for air pollutants.

Chemical Name	CAS No	RfC (mg/m3)	Residence time air (d)	**HTP**
Carbon monoxide	630-08-0	10.5	40	0.27
Hydrogen fluoride	7664-39-3	0.03	3	7.1
hydrochloric acid	7674-01-0	0.009	3	24
Ozone	10028-15-6	0.16	10	4.4
PM10		0.05	2	2.9
PM2.5		0.015	7	33
ammonia	7664-41-7	0.03	3.3	7.5
nitric acid	7697-37-2	0.04	0.12	4.2
phosphoric acid	7664-38-2	0.007	3	31
sulfate		0.025	3.3	9.8
SO2	7446-09-5	0.08	1.5	6.0
NO2	10102-44-0	0.1	0.5	4.3

The lifetime of 3 days used for hydrogen chloride, hydrogen fluoride, and phosphoric acid is a default. No chemical-specific data was found, and the true value is likely to be somewhat lower. CO is the most persistent chemical listed here, with a lifetime of 30-60 days (Seinfeld and Pandis 1998, p 86). For ozone, the clean-air lifetime of 10 days was selected, even though in highly polluted areas the lifetime can be under 1 day (Seinfeld and Pandis 1998, p. 41).

Modeling emissions to soil

Soil in CalTOX is modeled as three different compartments, each representing a different soil layer. Soil consists of three phases: a solid phase, usually composed of minerals and organic matter, a liquid phase, and an air phase. We assume that these phases are in chemical equilibrium with each other.

1. The ground-surface soil compartment is the top soil layer which is in direct exchange with the atmosphere and has a high organic carbon content. Pollutants from this soil layer can be transported onto plants via rain-splash. The ground-surface soil received dry deposition from the air and litter from the plants. Emissions to surface soil occur for example through spraying of pesticides onto surface soil.
2. The root-zone soil includes the roots of plants. It receives pollutants through percolation from the higher soil layer and the flow of phloem from roots to the soil. Emissions to root-zone soil occur when pesticides (e.g. nematocides) are injected into soil or sewage sludge is plowed under.
3. The vadose-zone is a densely packed soil zone which is water-logged. It does not contain any air and has a low organic matter content. For HTP calculations, this is the lowest layer considered. While transport to the ground water is taken into account, the ground water is not explicitly modeled and this transport is effectively treated as a permanent removal from the control volume. For ingestion of ground water or irrigation, the concentration of water in the vadose zone is used. In principle, deep-well injection could be treated as an emissions pathway to this low soil layer. We do not yet feel confident enough to treat this type of emissions in that way. This would probably require a better modeling of the aquifer.

The modeling of contaminated soils has been one of the regulatory applications of CalTOX, which is used by the California EPA to set clean-up standards for contaminated sites and to classify solid waste as hazardous or not. CalTOX therefore contains a fairly sophisticated algorithm to take into account the fate of pollutants in soil. This includes the ability to model soil saturated with pollutants. In this situation, the conventional fugacity approach no longer applies. These non-linear features are not used in HTP calculations, because HTP calculations essentially require a linear relationship between emissions and exposure.

We distinguish between emissions to agricultural soil and non-agricultural soil. When pollutants are emitted to agricultural soil, they can be taken up by plants directly and then passed on in the food chain to meat, milk, or eggs. This exposure is represented in CalTOX. In order to take into account emissions to non-agricultural soil, we had to extend the model. Emission to non-agricultural soil can still result in exposure through the food-chain, when pollutants are transported to agricultural land by air or irrigation water. Instead of introducing additional compartments for non-agricultural soil, we opted for simpler modification of the model in which the mass balance equations for soil and plant compartments are solved two times, first in the overall model and then for these compartments in steady state with the air, but without direct pollutant input. The second time we calculate the soil concentration of agricultural soil when pollutants are emitted to non-agricultural soil in the same general geographical area. The latter concentrations are then used for exposure calculations. The modifications required are modest and can be reviewed in the model, which can be downloaded from the web.

Modeling the atmospheric scale height

Hertwich and McKone (2001) have not only introduced a new, more general method for calculating the characteristic horizontal travel distance of a pollutant and provided a new interpretation for what this travel distance implies, they also proposed a method for calculating the atmospheric scale height. The atmospheric scale height is the characteristic height with which the concentration (or partial pressure) of a gas decreases with increasing elevation. This decrease is exponential, and at the elevation of the scale height, the concentration is e^{-1} times the ground-level concentration. Previously, the scale height had been calculated from a static equation that takes into account the effect of gravity and the molecular weight of a pollutant. This calculation was valid only for inert components of the atmosphere, like the noble gases, oxygen, and nitrogen. We introduced a steady-state model that takes into account the dynamics of transport, such as advection through dust and wet deposition, gas diffusion, as well as removal from the atmosphere through chemical degradation. It turns out that most pollutants have a lower scale height than other atmospheric constituents, because they decay and are subject to deposition processes. The scale height is depended on the presence of precipitation[4] and varies significantly from pollutant to pollutant. HTP calculations so far assume a uniform mixing of the pollutant up to a mixing height of 700 m. Instead of using this fixed atmospheric height, we use the scale height and hence get an air concentration that corresponds to the expected ground-level concentration in the more realistic case of an exponential decrease of the gas concentration with elevation.[5]

We have previously shown that this adjustment has a significant impact on the calculated HTP values. We believe that the consideration of the atmospheric scale height is warranted, because the scale height is based on a sound scientific theory, the conservation of mass. It may be that the simple exponential decrease of pollutants does not correctly represent the fate for some chemicals, because transport and transformation processes are elevation dependent, but it is in any case a better representation that a uniformly mixed atmosphere with a compartment size that is independent of the characteristic properties of a chemical. The introduction of the scale height substantially modifies the calculated HTP values (Hertwich and McKone 2001).

An update of the data

We have updated the underlying toxicity data for the chemicals following updates of this data by our principal data sources, the Integrated Risk Information System (U.S. EPA 1998) (available at toxnet.nlm.nih,gov) and those assembled by the state of California (CalEPA 1994), available at http://www.oehha.org/risk/chemicalDB/. Documentation on the toxicity data used can be found on www.scorecard.org. We also have added a few new chemicals and updated some physical-chemical data, but most of this data remains that same as in the original publication. An update of the toxicity value for toluene implies that all non-cancer HTP values have changed.

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[4] We distinguish between situations with and without rain, because rainfall significantly reduced the air concentration of ca. 120 hydrophilic pollutants through wet deposition. The surface water and soil concentrations are increased. Normally, multimedia models assume a steady-state situation in which there is constant rain, an assumption that leads to a significant underestimate of the air concentration and errors in the calculations of expected exposure. The potential dose is the weighted sum of the potential dose under rain and no rain conditions, assuming that it rains 20% of the time (Hertwich 2001).

[5] We impose a minimum scale height of 2 m. For hydrophilic pollutants we calculate lower scale heights than this under rain, but we judge those to be unrealistic. It would be nice to see some experimental work investigating the scale height.

Results and Discussion

Conventional air pollutants

The HTP values for chemicals that are treated only as air pollutants are reported in Table 1. The calculations are based on the assumption of a linear relationship between atmospheric concentrations and emissions, uniform mixing, and an equal atmospheric scale height for all chemicals. PM2.5 and PM10 are treated as chemical "species." Reliable data on average atmospheric residence times was difficult to find, so instead "typical" values reported in the literature were used. Note that similar problems affect multimedia calculations and many risk assessments.

Table 2 compares the results in this assessments with those reported by Huijbregts and colleagues (2000), Levy and colleagues (1999), the Environmental Priority System (Steen 1999), the Eco-Indicator 99 (Goedkoop and Spriensma 1999), Krewitt and colleagues (2001), and Spadaro and Rabl (1999). A comparison indicates that these assessments often give a higher score to NO2 than SO2. This may be in part because some of these studies consider population distributions, and if emissions occur in areas more populous than average the faster oxidation rate of NO2 results in a higher exposure to the more dangerous oxidized species. In addition, most studies do not consider particle size differences between sulfates and nitrates. The HTP of NO2 would be 10.8 if we used the same RfD for nitrates as for sulfates. Most studies report higher impacts for PM10 than for SO2. In our opinion, this is only justified if the PM10 is from combustion processes and hence mostly PM2.5. We recommend that for combustion processes, the HTP for PM2.5 is used even when only PM10 emissions are reported.

The HTP values for NO2 and SO2 would be 2.8 and 3.8 if we had used the atmospheric persistence and transformation data reported by Spadaro (Spadaro 1999). We refrained from doing so because we could not backcalculate the underlying data on deposition rates. An inconsistency with the data used for nitric acid and sulfate would have resulted.

We consider the reported HTP values a preliminary assessment. Their uncertainty is probably comparable with that of organic chemicals (Hertwich et al. 1999). It is crucially dependent on aerosol lifetime and toxicity. From our reading of the literature, no externality assessment or LCA impact factors sufficiently considers the current state of knowledge and understanding of aerosols. This is somewhat of a challenge, not only because of the complexity of the issue but also because of the rapid development of this field. Attempts to better address these issue should be made.

Table 2: Comparison of different impact assessments.

	Huijbregts	Levy et al	ORNL/ RFF (Levy et al. 1999)	EPS	EI 99 (H,A)	Krewitt, 1990, EU15avg.	Krewitt, 2010, EU15avg.	Spadaro &Rabl	this study
	1,4-DCB equ.	$/t	$/t	ELU/ kg	DALY /kg	YOLL/kt	YOLL/kt	Euro/kg	toluene equ.
NO2	1.2	770	150	2.13	8.87E-05	28.5	45.1	15.7	4.3
SO2	0.31	790	12	3.27	5.46E-05	27	28.7	10.2	6.0
PM10	0.096	12000	3800	36	3.75E-04	56.7	56.7	15.4	2.9
PM2.5					7.00E-04				33
NH3	0.1			2.90	8.50E-05				7.5
sulfate or SO3					4.37E-05				9.8
HNO3				1.55					4.3

Updated CalTOX results

The updated HTP values for non-cancer effects of toxic chemicals are reported in Table 3. The updated HTP values for carcinogens are reported in Table 4.

Conclusions

We have presented a significant update of the human toxicity potentials. This update includes a new approach to model chemicals that are treated as pure air emissions, the consideration of oxidation products of sulfur and nitrogen dioxide, new toxicity data, the evaluation of emissions to soil, and the consideration of the atmospheric scale height in CalTOX. The most significant change is considering the oxidation products of SO2 and NOx. For SO2, the HTP value is now 6 kg of toluene equivalents per kg of SO2, instead of 0.00045, for NOx the value is 4.3 instead of 0.0092. For LCA, this will have a big impact. The impact on the U.S. toxics release inventory (TRI) is less significant, because TRI does not list emission of these two chemicals. Ignoring these emissions, the most toxic emissions from coal fired power plants, for example, are still heavy metals, such as mercury and lead.

Table 3: Non-cancer human toxicity potential in toluene equivalents for emissions to different compartments. (agri= agricultural)

Chemical Name	CAS Number	Air	Surface water	Surface soil, agri	Rootzone soil, agri	Surface soil, non-agri	Rootzone soil, non-agri
1,1,1,2-Tetrachlorroethane	630-20-6	5,6 e+1	5,0 e+0	5,6 e+1	4,4 e+0	5,6 e+1	3,8 e+0
1,1,1-Trichloroethane	71-55-6	3,0 e+1	2,8 e+1	3,0 e+1	3,3 e+0	3,0 e+1	3,1 e+0
1,1,2,2-Tetrachloroethane	79-34-5	2,8 e+0	2,5 e+0	2,8 e+0	1,1 e+0	2,8 e+0	7,5 e-1
1,1,2-Trichloroethane	79-00-5	4,9 e+0	1,4 e+1	5,1 e+0	1,5 e+1	5,0 e+0	1,8 e+0
1,1-Dichloroethane	75-34-3	3,9 e+0	4,0 e+0	3,9 e+0	2,4 e-1	3,9 e+0	1,5 e-1
1,1-Dichloroethylene	75-35-4	9,5 e+0	2,4 e+1	9,5 e+0	4,7 e+0	9,5 e+0	4,3 e-1
1,1-Difluoro-1-Chloroethane	75-68-3	1,0 e+0	8,6 e-3	9,7 e-1	4,5 e-5	9,7 e-1	4,3 e-5
1,1-Dimethylhydrazine	57-14-7	1,9 e+3	1,7 e+2	1,6 e+2	2,0 e+1	1,6 e+2	4,5 e+0
1,2,4,5-Tetrachlorobenzene	95-94-3	8,9 e+3	1,9 e+4	8,3 e+3	5,6 e+3	8,3 e+3	5,3 e+3
1,2,4-Trichlorobenzene	120-82-1	9,6 e+0	7,8 e+1	1,0 e+1	1,9 e+1	9,7 e+0	3,6 e+0
1,2,4-Trimethylbenzene	95-63-6	1,1 e+1	3,3 e+2	1,1 e+1	4,4 e+1	1,1 e+1	3,2 e+0
1,2-Dibromoethane	106-93-4	1,5 e+3	1,3 e+3	1,5 e+3	1,8 e+2	1,5 e+3	1,5 e+2
1,2-Dichlorobenzene (O)	95-50-1	8,2 e+0	1,0 e+1	8,2 e+0	6,1 e+0	8,2 e+0	3,9 e+0
1,2-Dichloroethane	107-06-2	4,2 e+0	4,8 e+0	4,2 e+0	5,4 e-1	4,2 e+0	3,8 e-1
1,2-Dichloroethylene	540-59-0	8,6 e+0	1,4 e+1	8,6 e+0	1,6 e+0	8,5 e+0	4,7 e-1
1,2-Dichloropropane	78-87-5	2,2 e+2	2,6 e+2	2,2 e+2	2,0 e+2	2,2 e+2	8,4 e+1
1,2-Dinitrobenzene	528-29-0	8,4 e+2	2,3 e+2	2,2 e+2	1,3 e+2	2,1 e+2	1,1 e+2
1,3-Butadiene	106-99-0	5,5 e+0	1,9 e+1	5,5 e+0	1,4 e+0	5,5 e+0	1,8 e-2
1,3-Dichlorobenzene	541-73-1	6,0 e+0	7,4 e+0	6,0 e+0	1,6 e+0	6,0 e+0	1,0 e+0
1,3-Dichloropropene	542-75-6	1,3 e+1	4,8 e+1	1,3 e+1	9,1 e-1	1,3 e+1	9,0 e-2
1,3-Phenylenediamine	108-45-2	5,8 e+1	8,7 e+0	7,1 e+0	2,0 e+0	7,1 e+0	1,9 e+0
1,4-Dichlorobenzene (P)	106-46-7	2,2 e+0	1,3 e+0	2,2 e+0	2,7 e+0	2,2 e+0	1,6 e+0
1,4-Dinitrobenzene	100-25-4	1,7 e+2	2,1 e+2	1,6 e+2	4,2 e+1	1,6 e+2	2,2 e+1
1,4-Dioxane	123-91-1	5,1 e-2	5,6 e-2	5,1 e-2	4,2 e-2	4,8 e-2	4,1 e-3
1-Chloro-2,3-Epoxypropane	106-89-8	6,4 e+2	2,4 e+2	5,6 e+2	2,5 e+1	5,6 e+2	2,3 e+1
1-Chlorobutane	109-69-3	6,1 e-1	8,6 e-1	6,1 e-1	2,0 e+0	6,1 e-1	5,7 e-1
1-Naphtyl N-Methylcarbamate	63-25-2	4,1 e-2	4,2 e-1	4,3 e-2	5,9 e-2	4,2 e-2	4,1 e-3
2,2-(4,4'-Dihydroxydiphenyl)Propane	80-05-7	7,9 e+0	3,8 e-1	5,8 e-1	3,1 e+0	4,1 e-1	1,8 e+0
2,3,4,6-Tetrachlorophenol	58-90-2	2,9 e+1	5,6 e+1	1,1 e+1	5,7 e+0	1,1 e+1	4,6 e+0
2,3,4,7,8-Pentachlorodibenzofuran	57117-31-4	2,2 e+8	1,0 e+9	1,0 e+8	4,4 e+8	3,8 e+7	3,5 e+7
2,3,7,8-Tcdd	1746-01-6	8,8 e+11	4,9 e+11	8,8 e+11	6,3 e+12	1,4 e+11	1,4 e+11
2,4,5-T	93-76-5	6,3 e+1	4,8 e+0	4,8 e+0	1,2 e+1	4,2 e+0	7,4 e+0
2,4,5-Trichlorophenol	95-95-4	6,5 e+0	7,0 e+0	3,9 e+0	1,5 e+0	3,8 e+0	6,5 e-1
2,4,6-Trichlorophenol	88-06-2	1,3 e+1	2,1 e-1	7,9 e+0	1,5 e+0	7,8 e+0	5,0 e-1
2,4,6-Trinitrophenol	88-89-1	6,1 e+3	7,1 e+2	9,7 e+2	2,3 e+3	9,3 e+2	2,1 e+3
2,4,6-Trinitrotoluene	118-96-7	5,1 e+2	3,0 e+0	4,4 e+1	1,7 e+2	4,1 e+1	1,5 e+2
2,4-D [Acetic Acid (2,4-Dichlorophenoxy)-]	94-75-7	4,5 e+1	1,1 e+0	2,2 e+0	6,2 e+0	2,1 e+0	5,3 e+0
2,4-Dichlorophenol	120-83-2	5,1 e+1	1,5 e-1	2,5 e+1	1,2 e+0	2,5 e+1	6,2 e-1
2,4-Dimethylphenol	105-67-9	1,2 e+0	8,7 e-1	6,9 e-1	4,0 e-2	6,9 e-1	1,9 e-2
2,4-Dinitrophenol	51-28-5	9,4 e+1	7,8 e+0	3,2 e+1	4,5 e+1	3,1 e+1	3,6 e+1
2,4-Dinitrotoluene	121-14-2	1,0 e+2	9,2 e-1	3,3 e+1	4,1 e+1	3,2 e+1	2,9 e+1
2,6-Dimethylpnenol	576-26-1	9,8 e+1	4,5 e+2	2,9 e+2	7,8 e+2	2,2 e+2	1,0 e+2
2,6-Dinitrotoluene	606-20-2	2,0 e+2	9,4 e-1	3,7 e+1	9,1 e+1	3,4 e+1	6,9 e+1
2-Chlor-1,3-Butadiene	126-99-8	1,2 e+1	2,9 e+1	1,2 e+1	2,3 e+1	1,2 e+1	1,3 e+0
2-Chlorophenol	95-57-8	2,1 e+1	5,6 e+1	1,2 e+1	4,0 e-1	1,2 e+1	2,9 e-1
2-Chloropropane	75-29-6	1,1 e+1	1,4 e+1	1,1 e+1	3,4 e+1	1,1 e+1	9,6 e+0
2-Methoxyethanol	109-86-4	6,1 e+0	2,0 e+1	6,2 e+0	5,9 e-1	6,2 e+0	1,3 e-2
2-Nitroaniline	88-74-4	8,6 e+2	3,6 e+2	3,4 e+2	4,5 e+1	3,4 e+2	3,1 e+1
2-Nitropropane	79-46-9	5,8 e+0	1,5 e+1	6,2 e+0	6,3 e+0	6,1 e+0	1,4 e+0
2-Nitrotoluene	88-72-2	4,6 e+0	1,4 e+0	4,2 e+0	2,9 e+0	4,1 e+0	1,0 e+0
2-Phenylphenol	90-43-7	2,6 e-1	7,2 e-1	2,2 e-1	9,1 e-2	2,2 e-1	3,0 e-3
3-Nitrotoluene	99-08-1	3,8 e+1	4,7 e+1	4,0 e+1	9,3 e+1	3,8 e+1	3,4 e+1
4,4'-Diamino Ditan	101-77-9	2,8 e+0	4,8 e-2	1,5 e-2	9,5 e-2	1,5 e-2	9,0 e-2
4,6-Dinitro-O-Cresol	534-52-1	1,7 e+3	5,6 e+1	5,0 e+2	9,4 e+1	5,0 e+2	8,8 e+1

4-Nitrophenol	100-02-7	2,1 e+1	6,0 e+0	2,1 e+1	3,4 e+0	2,1 e+1	4,8 e-2
Abamectin	71751-41-2	4,0 e+3	3,1 e+1	3,3 e-1	1,1 e+2	5,4 e-2	8,3 e-1
Acenaphthene	83-32-9	4,5 e-1	2,6 e+0	5,0 e-1	1,9 e+0	4,0 e-1	1,7 e-1
Acephate	30560-19-1	1,4 e+2	2,6 e+1	1,1 e+1	1,1 e-1	1,1 e+1	7,4 e-2
Acetaldehyde	75-07-0	9,3 e+0	5,1 e+0	8,4 e+0	5,1 e-2	8,4 e+0	1,3 e-2
Acetone	67-64-1	7,9 e-2	7,6 e-2	7,3 e-2	1,3 e-3	7,3 e-2	3,0 e-4
Acetonitrile	75-05-8	3,0 e+1	1,5 e+1	2,7 e+1	5,3 e-1	2,7 e+1	4,2 e-1
Acetophenone	98-86-2	2,5 e+0	6,3 e-1	1,5 e+0	7,6 e-2	1,5 e+0	6,9 e-2
Acrolein	107-02-8	4,7 e+3	5,8 e+3	4,6 e+3	1,7 e+2	4,6 e+3	6,7 e+1
Acrylamide	79-06-1	2,0 e+3	2,5 e+1	3,9 e+0	4,0 e+0	3,9 e+0	1,2 e+0
Acrylic Acid	79-10-7	6,2 e+1	2,2 e-1	9,6 e+0	4,2 e-1	9,6 e+0	4,2 e-1
Acrylonitrile	107-13-1	3,8 e+1	1,9 e+1	3,6 e+1	1,7 e+0	3,6 e+1	6,2 e-1
Aldicarb	116-06-3	6,2 e+2	7,5 e+2	6,6 e+2	3,0 e+2	6,6 e+2	2,7 e+2
Aldrin	309-00-2	7,2 e+5	2,6 e+6	9,4 e+5	2,2 e+6	5,4 e+5	4,9 e+5
Allyl Alcohol	107-18-6	4,3 e+0	1,0 e+0	2,1 e+0	4,6 e-2	2,1 e+0	2,5 e-2
Allyl Chloride	107-05-1	8,8 e+1	4,5 e+1	8,8 e+1	6,8 e+0	8,8 e+1	6,6 e-1
Allyl Trichloride	96-18-4	4,3 e+1	5,4 e+1	4,3 e+1	2,4 e+1	4,3 e+1	1,4 e+1
Alpha-HCH (Alpha-BHC)	319-84-6	5,9 e+1	1,1 e+2	2,5 e+1	1,1 e+1	2,4 e+1	3,1 e+0
Aluminum (Fume Or Dust)	7429-90-5	1,2 e+4	9,3 e+0	8,3 e+0	3,1 e+0	7,2 e+0	6,5 e-1
Ammonia	7664-41-7	7,5 e+0	3,2 e-2	1,8 e+0	1,5 e-3	1,8 e+0	1,1 e-3
Anilazine	101-05-3	1,4 e+3	5,8 e+1	1,7 e+0	4,4 e+0	1,7 e+0	1,4 e+0
Aniline	62-53-3	9,1 e+1	5,7 e+1	5,2 e+1	3,8 e+0	5,2 e+1	1,9 e+0
Anthracene	120-12-7	1,8 e-1	8,1 e-3	7,2 e-1	3,1 e+0	1,3 e-1	1,1 e-1
Antimony	7440-36-0	7,4 e+3	1,5 e+3	1,5 e+3	1,4 e+3	9,8 e+2	1,2 e+2
Antimony Compounds	ADQ500	7,4 e+3	1,5 e+3	1,5 e+3	1,4 e+3	9,8 e+2	1,2 e+2
Aroclor 1016	12674-11-2	3,0 e+3	2,0 e+5	9,6 e+1	7,1 e+1	9,5 e+1	9,6 e+0
Arsenic	7440-38-2	8,4 e+4	2,0 e+4	8,3 e+4	1,3 e+5	1,5 e+4	8,7 e+3
Arsenic Compounds	ARF750	8,4 e+4	2,0 e+4	8,3 e+4	1,3 e+5	1,5 e+4	8,7 e+3
Atrazine	1912-24-9	1,7 e+1	1,5 e-2	3,3 e+0	1,9 e+1	2,3 e+0	1,3 e+1
Azinphos-Methyl	86-50-0	2,6 e+2	6,4 e+0	9,8 e+0	6,1 e+1	8,7 e+0	5,2 e+1
Barium	7440-39-3	3,7 e+2	4,8 e+1	3,8 e+1	2,5 e+1	2,9 e+1	6,4 e+0
Barium Compounds	BAK500	3,7 e+2	4,8 e+1	3,8 e+1	2,5 e+1	2,9 e+1	6,4 e+0
Baygon	114-26-1	6,2 e+1	8,9 e+0	4,1 e+0	7,4 e+0	4,0 e+0	6,9 e+0
Benomyl	17804-35-2	6,6 e+0	4,1 e-1	3,5 e-1	2,5 e+0	3,1 e-1	2,2 e+0
Bentazone	25057-89-0	7,8 e+2	1,5 e+3	1,1 e+3	6,2 e+1	1,1 e+3	6,2 e+1
Benzene	71-43-2	8,1 e+0	6,1 e+0	8,1 e+0	3,6 e+0	8,0 e+0	9,0 e-1
Benzene, M-Dimethyl	108-38-3	4,1 e-1	5,0 e-1	4,1 e-1	4,6 e-2	4,1 e-1	5,0 e-3
Benzene, O-Dimethyl	95-47-6	5,4 e-1	6,0 e-1	5,4 e-1	4,2 e-2	5,4 e-1	7,1 e-3
Benzene, P-Dimethyl	106-42-3	5,3 e-1	5,9 e-1	5,3 e-1	4,8 e-2	5,3 e-1	5,9 e-3
Benzenethiol	108-98-5	8,2 e+3	1,9 e+4	9,2 e+3	7,0 e+4	8,3 e+3	7,6 e+3
Benzidine	92-87-5	1,0 e+2	5,3 e+0	3,1 e+0	5,0 e+0	3,1 e+0	4,8 e+0
Benzoic Acid	65-85-0	2,0 e-2	2,4 e-3	9,6 e-3	7,6 e-4	9,6 e-3	5,7 e-4
Benzyl Chloride	100-44-7	2,1 e+1	1,9 e+0	2,0 e+1	3,0 e+0	2,0 e+1	1,7 e+0
Beryllium	7440-41-7	2,4 e+4	5,4 e+2	9,5 e+2	1,1 e+3	3,2 e+2	1,3 e+2
Beryllium Compounds	BFQ500	2,4 e+4	5,4 e+2	9,5 e+2	1,1 e+3	3,2 e+2	1,3 e+2
Beta-HCH (Beta-BHC)	319-85-7	1,5 e+3	2,0 e+3	5,5 e+2	3,6 e+2	5,2 e+2	1,4 e+2
Bifenthrin	82657-04-3	9,7 e+1	2,6 e+2	2,3 e+1	2,7 e+2	1,1 e+1	4,4 e+0
Biphenyl	92-52-4	9,8 e-1	3,4 e+0	8,8 e-1	1,5 e-1	8,8 e-1	2,2 e-2
Bis(2-Chloroethyl)Ether	111-44-4	2,7 e+0	4,3 e+0	2,9 e+0	2,9 e+0	2,8 e+0	9,6 e-1
Bis(2-Ethylhexyl)Phthalate	117-81-7	3,3 e+1	9,0 e+0	3,0 e-1	4,8 e+0	2,6 e-1	4,2 e-2
Bis(Tributyltin) Oxide	56-35-9	2,3 e+3	9,5 e+3	8,3 e+2	8,7 e+2	8,0 e+2	3,5 e+2
Bromodichloromethane	75-27-4	2,8 e+2	2,1 e+2	2,7 e+2	6,9 e+1	2,7 e+2	6,7 e+1
Bromoform	75-25-2	2,0 e+2	2,1 e+2	2,0 e+2	6,5 e+1	2,0 e+2	6,0 e+1
Bromoxynil	1689-84-5	3,1 e+1	1,1 e+1	1,8 e+0	1,3 e+0	1,8 e+0	1,0 e+0
Butanol	71-36-3	7,1 e-1	1,7 e-1	4,0 e-1	1,1 e-2	4,0 e-1	8,0 e-3
Butyl Benzyl Phthalate	85-68-7	2,9 e+0	8,2 e-2	3,1 e-3	7,6 e-2	2,9 e-3	2,0 e-3
Butyric Acid, 4-(2,4-Dichlorophenoxy)	94-82-6	7,6 e+1	6,9 e+0	4,1 e-1	8,4 e-1	4,1 e-1	4,2 e-1
Cadmium	7440-43-9	1,9 e+6	1,4 e+5	1,9 e+6	3,7 e+7	1,7 e+5	1,7 e+5
Cadmium Compounds	CAE750	1,9 e+6	1,4 e+5	1,9 e+6	3,7 e+7	1,7 e+5	1,7 e+5
Captafol	2425-06-1	2,2 e+2	1,8 e+2	5,0 e+0	6,0 e+0	5,0 e+0	3,1 e+0
Captan	133-06-2	2,3 e-1	3,6 e-3	1,4 e-1	7,8 e-2	1,4 e-1	2,5 e-2
Carbendazim	10605-21-7	4,2 e+1	1,4 e+1	1,2 e+1	1,8 e+1	1,2 e+1	1,6 e+1
Carbofuran	1563-66-2	1,8 e+2	5,2 e+1	1,6 e+2	8,0 e+0	1,6 e+2	7,8 e+0

Carbon Disulfide	75-15-0	1,4 e+0	2,0 e+0	1,4 e+0	8,2 e-1	1,3 e+0	2,7 e-1
Carbon Monoxide	630-08-0	2,7 e-1					
Carbon Tetrachloride	56-23-5	2,3 e+3	2,3 e+3	2,3 e+3	3,5 e+2	2,3 e+3	3,4 e+2
Carbonyl Chloride	75-44-5	3,0 e+5	8,2 e+1	2,3 e+5	4,0 e+2	2,3 e+5	3,9 e+2
Cellosolve	110-80-5	1,3 e+0	8,2 e-2	2,8 e-1	2,6 e-2	2,8 e-1	1,6 e-2
Cfc-11	75-69-4	9,6 e+0	9,1 e+0	9,6 e+0	6,1 e-1	9,6 e+0	5,9 e-1
Cfc-12	75-71-8	4,6 e+0	3,8 e+0	4,6 e+0	4,4 e-1	4,6 e+0	1,9 e-1
Chlordane	57-74-9	1,0 e+5	2,4 e+5	1,2 e+5	1,6 e+5	1,0 e+5	9,8 e+4
Chlorfenvinphos	470-90-6	3,6 e+2	1,8 e+2	8,2 e+1	3,4 e+1	8,0 e+1	1,2 e+1
Chlorinated Fluorocarbon (Freon 113)	76-13-1	5,9 e+0	5,6 e+0	5,9 e+0	1,0 e+0	5,9 e+0	1,0 e+0
Chloroacetic Acid	79-11-8	1,9 e+2	1,7 e+0	3,3 e+0	1,4 e+0	3,2 e+0	1,3 e+0
Chlorobenzene	108-90-7	9,5 e-1	5,3 e+0	9,6 e-1	1,4 e+0	9,6 e-1	1,6 e-1
Chlorodibromomethane	124-48-1	1,4 e+2	1,2 e+2	1,4 e+2	4,5 e+1	1,4 e+2	4,3 e+1
Chlorodifluoromethane (Freon-22)	75-45-6	1,4 e+0	1,1 e-2	1,4 e+0	1,3 e+0	1,4 e+0	1,2 e+0
Chloroethane	75-00-3	7,1 e-2	7,3 e-2	7,0 e-2	5,3 e-4	7,0 e-2	2,2 e-4
Chloroform	67-66-3	1,4 e+1	1,6 e+1	1,4 e+1	1,4 e+0	1,4 e+1	6,1 e-1
Chlorothalonil	1897-45-6	1,5 e+1	5,9 e-1	1,4 e+0	1,7 e+0	1,3 e+0	1,2 e+0
Chlorpropham	101-21-3	3,5 e+0	1,1 e+0	4,1 e-1	3,7 e-1	3,9 e-1	1,9 e-1
Chlorpyriphos	2921-88-2	2,2 e+2	6,4 e+2	2,1 e+1	3,6 e+1	2,0 e+1	8,1 e-1
Chromium	7440-47-3	2,4 e+3	2,6 e+2	5,3 e+2	6,2 e+2	1,5 e+2	7,1 e+1
Chromium Compounds	CMJ500	2,4 e+3	2,6 e+2	5,3 e+2	6,2 e+2	1,5 e+2	7,1 e+1
Cis-1,2-Dichloroethylene	156-59-2	1,5 e+1	2,1 e+1	1,5 e+1	5,6 e+0	1,5 e+1	1,2 e+0
Cis-1,3-Dichloropropene	10061-01-5	1,4 e+1	5,1 e+1	1,4 e+1	3,6 e-1	1,4 e+1	4,0 e-2
Cobalt	7440-48-4	3,1 e+4	6,5 e+1	9,5 e+1	8,5 e+1	4,9 e+1	1,3 e+1
Cobalt Compounds	CNB850	3,1 e+4	6,5 e+1	9,5 e+1	8,5 e+1	4,9 e+1	1,3 e+1
Copper	7440-50-8	1,1 e+4	6,6 e+3	3,6 e+3	1,5 e+3	3,5 e+3	1,3 e+3
Copper Compounds	CNK750	1,1 e+4	6,6 e+3	3,6 e+3	1,5 e+3	3,5 e+3	1,3 e+3
Coumaphos	56-72-4	1,9 e+3	9,7 e+2	4,3 e+1	7,0 e+1	4,2 e+1	1,3 e+1
Cumene	98-82-8	4,1 e-1	3,8 e-1	4,1 e-1	3,6 e-2	4,1 e-1	5,3 e-3
Cyanazine	21725-46-2	2,7 e+2	5,7 e+1	4,1 e+1	2,1 e+1	4,0 e+1	2,0 e+1
Cyclohexane	110-82-7	3,9 e-2	1,8 e-1	4,0 e-2	4,7 e-2	4,0 e-2	5,3 e-3
Cyclohexanone	108-94-1	1,6 e-2	8,1 e-3	1,4 e-2	3,3 e-4	1,4 e-2	2,7 e-4
Cygon	60-51-5	1,6 e+3	5,7 e+2	4,2 e+2	2,1 e+2	4,1 e+2	1,9 e+2
Cypermethrin	52315-07-8	7,8 e+2	1,7 e+2	3,2 e+2	1,4 e+3	1,6 e+2	1,8 e+0
Cyromazine	66215-27-8	8,6 e+1	3,8 e+1	3,3 e+1	9,8 e+0	3,2 e+1	8,6 e+0
Ddt	50-29-3	3,5 e+4	6,6 e+4	3,5 e+4	4,3 e+4	2,9 e+4	2,8 e+4
Ddvp (Dichlorvos)	62-73-7	3,5 e+2	1,6 e+2	3,0 e+2	8,2 e-2	3,0 e+2	4,0 e-2
Deltamethrin	52918-63-5	5,0 e+1	1,2 e+0	3,1 e-2	8,5 e+0	1,1 e-2	2,3 e-1
Demeton	8065-48-3	8,1 e+3	7,8 e+2	5,1 e+2	5,4 e+2	5,0 e+2	4,9 e+2
Diazinon	333-41-5	1,3 e+3	9,8 e+2	6,6 e+2	1,0 e+2	6,5 e+2	7,7 e+1
Dibromomethane	74-95-3	7,9 e+1	8,4 e+1	7,9 e+1	1,2 e+0	7,9 e+1	1,1 e+0
Dicamba	1918-00-9	1,9 e+1	4,3 e+0	2,4 e+0	1,4 e+0	2,4 e+0	1,3 e+0
Dichlorobenzene (Mixed Isomers)	25321-22-6	9,2 e+0	9,7 e+0	2,4 e+0	1,6 e+0	2,3 e+0	9,2 e-1
Dichlorprop	120-36-5	7,3 e+1	3,0 e+1	2,6 e+0	2,0 e+0	2,6 e+0	7,9 e-1
Dicofol	115-32-2	3,1 e+3	6,7 e+3	2,2 e+3	6,8 e+1	2,2 e+3	4,6 e+1
Dieldrin	60-57-1	1,3 e+5	4,8 e+5	1,5 e+5	1,6 e+5	1,3 e+5	7,5 e+4
Diethanolamine	111-42-2	3,1 e+2	1,7 e+0	1,2 e+0	5,2 e-1	1,1 e+0	1,2 e-1
Diethyl Phthalate	84-66-2	3,9 e-1	3,1 e-1	2,2 e-1	5,0 e-2	2,2 e-1	3,9 e-2
Dimethyl Phthalate	131-11-3	2,3 e-2	1,7 e-3	4,1 e-3	4,0 e-4	4,1 e-3	3,5 e-4
Dimethylamine	124-40-3	4,1 e+1	1,0 e+1	3,3 e+1	6,2 e-2	3,3 e+1	4,9 e-2
Dimethylphylamine	121-69-7	1,2 e+1	4,8 e+0	1,2 e+1	2,0 e+1	1,1 e+1	3,5 e+0
Di-N-Butyl Phthalate	84-74-2	1,1 e+1	1,8 e+0	4,9 e+0	6,3 e+0	4,0 e+0	8,7 e-1
Dinitrobutyl Phenol	88-85-7	9,1 e+2	7,2 e+2	6,7 e+2	1,5 e+2	6,7 e+2	1,3 e+2
Di-N-Octyl Phthalate	117-84-0	2,6 e+4	1,6 e+5	8,2 e+3	1,5 e+6	1,1 e+2	2,4 e+1
Diphenylamine	122-39-4	1,4 e+1	1,4 e+1	2,8 e+0	9,6 e-1	2,8 e+0	3,8 e-1
Disulfothon	298-04-4	1,3 e+4	4,3 e+3	2,5 e+2	4,0 e+2	2,4 e+2	7,9 e+1
Diuron	330-54-1	3,8 e+2	1,2 e+2	1,1 e+2	2,8 e+2	1,0 e+2	2,1 e+2
Endosulfan	115-29-7	1,5 e+1	2,3 e+1	1,5 e+1	2,8 e+1	1,2 e+1	4,7 e+0
Endrin	72-20-8	1,4 e+4	4,4 e+4	1,8 e+4	1,8 e+4	1,6 e+4	1,0 e+4
Ethoprop	13194-48-4	1,5 e+4	1,4 e+4	9,5 e+3	8,4 e+2	9,5 e+3	5,8 e+2
Ethyl Acetate	141-78-6	9,2 e-2	2,4 e-2	8,6 e-2	1,3 e-3	8,6 e-2	1,0 e-3

Ethyl Acrylate	140-88-5	1,6 e+0	7,1 e-1	1,5 e+0	3,3 e-2	1,5 e+0	1,4 e-2
Ethyl Dipropylthiocarbamate	759-94-4	2,0 e+0	2,3 e+0	1,9 e+0	5,1 e-1	1,8 e+0	9,7 e-2
Ethyl Ether (Diethyl Ether)	60-29-7	2,3 e-1	3,7 e-1	2,3 e-1	7,2 e-3	2,3 e-1	3,0 e-3
Ethyl Methacrylate	97-63-2	6,6 e-1	1,5 e+0	6,7 e-1	1,2 e+1	6,6 e-1	5,9 e-1
Ethylbenzene	100-41-4	2,7 e-1	3,5 e-1	2,7 e-1	1,8 e-2	2,7 e-1	2,6 e-3
Ethylene Glycol	107-21-1	2,5 e-1	4,2 e-3	2,0 e-2	6,5 e-4	2,0 e-2	1,3 e-4
Ethylene Oxide	75-21-8	3,4 e+2	1,7 e+2	3,3 e+2	5,4 e+1	3,2 e+2	2,7 e+1
Ethylenethiourea	96-45-7	4,6 e+3	4,0 e+2	2,9 e+2	1,3 e+2	2,8 e+2	4,7 e+1
Fenitrothion	122-14-5	4,8 e+2	1,2 e+2	1,8 e+1	3,8 e+1	1,7 e+1	2,2 e+1
Fenthion	55-38-9	3,0 e+3	1,4 e+4	2,0 e+3	1,8 e+2	2,0 e+3	8,1 e+1
Fentin Acetate	900-95-8	1,1 e+3	5,9 e+2	5,2 e+1	3,7 e+2	4,2 e+1	2,0 e+2
Fluoranthene	206-44-0	2,2 e+1	7,9 e+0	1,7 e+1	3,9 e+1	9,8 e+0	8,4 e+0
Fluorene	86-73-7	3,2 e+0	1,7 e+1	2,0 e+0	3,2 e+0	1,8 e+0	5,8 e-1
Folpet	133-07-3	5,4 e+0	2,4 e-2	9,4 e-2	5,1 e-1	7,7 e-2	2,2 e-1
Formaldehyde	50-00-0	1,6 e+1	2,9 e-1	4,2 e+0	1,1 e-1	4,2 e+0	1,1 e-1
Formic Acid	64-18-6	6,4 e-2	1,8 e-3	1,6 e-2	1,3 e-4	1,6 e-2	1,2 e-4
Furan	110-00-9	4,5 e+1	4,1 e+1	4,5 e+1	1,3 e+0	4,5 e+1	2,9 e-1
Gamma-HCH (Lindane)	58-89-9	2,9 e+3	5,4 e+3	2,4 e+3	1,0 e+3	2,3 e+3	5,2 e+2
Glyphosate	1071-83-6	1,9 e+1	1,4 e+2	1,5 e+1	6,5 e+0	1,5 e+1	1,0 e+0
Heptachlor	76-44-8	2,5 e+2	1,8 e+3	5,2 e+2	2,0 e+3	2,9 e+2	2,0 e+2
Heptachlor Epoxide	1024-57-3	8,8 e+3	3,4 e+5	1,1 e+4	2,0 e+4	9,3 e+3	8,6 e+3
Hexachloro-1,3-Butadiene	87-68-3	4,3 e+3	3,0 e+4	4,3 e+3	4,1 e+3	4,3 e+3	4,0 e+3
Hexachlorobenzene	118-74-1	2,1 e+4	3,3 e+4	2,1 e+4	2,0 e+4	2,0 e+4	2,0 e+4
Hexachlorocyclopentadiene	77-47-4	1,3 e+2	1,2 e+2	9,4 e+1	1,3 e+2	9,2 e+1	6,4 e+1
Hexachloroethane	67-72-1	5,5 e+3	4,9 e+3	5,1 e+3	2,9 e+3	5,1 e+3	2,9 e+3
Hexane	110-54-3	8,1 e-1	7,1 e+0	8,1 e-1	7,7 e+0	8,0 e-1	4,3 e-1
Hexone	108-10-1	1,4 e+0	3,5 e-1	1,3 e+0	2,7 e-2	1,3 e+0	2,0 e-2
Hydrazine	302-01-2	3,9 e+2	1,4 e+2	1,4 e+2	4,6 e-1	1,4 e+2	7,3 e-2
Hydrocyanic Acid	74-90-8	1,7 e+3	1,6 e+3	1,7 e+3	7,2 e+1	1,7 e+3	6,0 e+1
Hydrogen Chloride	7647-01-0	2,4 e+1	1,2 e-1	1,0 e-1	1,9 e-16	1,0 e-1	1,9 e-16
Hydrogen Fluoride	7664-39-3	7,1 e+0					
Hydrogen Sulphide (H2S)	7783-06-4	3,1 e-2	9,0 e+0	3,1 e-2	2,2 e-12	3,1 e-2	9,2 e-14
Hydroquinone	123-31-9	7,5 e+0	1,5 e-3	1,4 e-2	1,1 e-1	1,3 e-2	1,0 e-1
Iprodione	36734-19-7	1,5 e+1	4,9 e-1	5,2 e-1	2,0 e+0	4,6 e-1	1,5 e+0
Isobutanol	78-83-1	2,6 e-1	4,4 e-2	1,6 e-1	1,8 e-3	1,6 e-1	1,6 e-3
Isophorone	78-59-1	3,2 e-2	1,6 e-1	6,7 e-2	1,6 e-2	6,6 e-2	2,5 e-3
Isopropyl Alcohol	67-63-0	1,8 e-2	4,2 e-3	8,7 e-3	5,9 e-4	8,7 e-3	9,0 e-5
Kepone	143-50-0	1,4 e+4	1,5 e+5	9,0 e+3	9,1 e+3	8,7 e+3	5,3 e+3
Lead	7439-92-1	5,8 e+5	4,2 e+4	5,4 e+5	1,6 e+7	5,0 e+4	5,0 e+4
Lead Compounds	LCT000	5,8 e+5	4,2 e+4	5,4 e+5	1,6 e+7	5,0 e+4	5,0 e+4
Lead(Organic)	EDF-230	2,8 e+5	5,8 e+6	2,8 e+5	2,3 e+6	2,8 e+5	1,1 e+5
Linuron	330-55-2	2,9 e+2	2,1 e+2	9,1 e+1	7,6 e+1	8,8 e+1	5,9 e+1
Malathion	121-75-5	2,4 e+1	7,2 e+0	3,0 e-1	2,7 e+0	2,9 e-1	2,2 e+0
Maleic Anhydride	108-31-6	2,2 e+1	4,1 e-6	2,0 e-7	3,9 e-6	1,7 e-7	3,7 e-6
Manganese	7439-96-5	3,1 e+3	3,5 e+0	3,4 e+0	2,1 e+0	2,7 e+0	2,6 e-1
Manganese Compounds	MAR500	3,1 e+3	3,5 e+0	3,4 e+0	2,1 e+0	2,7 e+0	2,6 e-1
M-Cresol	108-39-4	1,3 e+1	7,7 e-1	4,1 e+0	7,8 e-1	4,1 e+0	7,3 e-1
M-Dinitrobenzene	99-65-0	4,3 e+3	6,2 e+4	9,7 e+2	9,0 e+3	8,3 e+2	1,0 e+3
Mecoprop	7085-19-0	4,2 e+2	1,4 e+1	8,8 e+0	5,6 e+0	8,7 e+0	4,9 e+0
Mercury	7439-97-6	1,4 e+7	1,3 e+7	1,4 e+7	1,4 e+7	1,4 e+7	1,4 e+7
Mercury Compounds	EDF-033	1,4 e+7	1,3 e+7	1,4 e+7	1,4 e+7	1,4 e+7	1,4 e+7
Methanol	67-56-1	9,9 e-2	1,6 e-2	5,3 e-2	4,1 e-4	5,3 e-2	1,4 e-4
Methomyl	16752-77-5	2,4 e+1	2,1 e+1	1,5 e+1	1,9 e+0	1,5 e+1	1,8 e+0
Methoxone	94-74-6	1,1 e+3	6,2 e+1	1,8 e+1	7,4 e+0	1,8 e+1	5,2 e-1
Methoxychlor	72-43-5	7,1 e+1	1,6 e+0	4,6 e+0	6,5 e+1	2,4 e+0	2,0 e+0
Methyl Acetate	79-20-9	8,1 e-2	2,0 e-2	7,5 e-2	9,2 e-4	7,5 e-2	7,0 e-4
Methyl Acrylate	96-33-3	8,0 e-1	3,3 e-1	7,5 e-1	1,3 e-2	7,5 e-1	5,6 e-3
Methyl Bromide	74-83-9	1,6 e+3	9,0 e+2	1,6 e+3	9,2 e+0	1,6 e+3	8,2 e+0
Methyl Chloride	74-87-3	5,7 e+1	3,3 e+1	5,7 e+1	2,0 e-1	5,7 e+1	1,6 e-1
Methyl Ethyl Ketone	78-93-3	5,0 e-2	1,3 e-2	4,0 e-2	4,7 e-4	4,0 e-2	3,5 e-4
Methyl Methacrylate	80-62-6	5,3 e-1	9,3 e-1	5,3 e-1	4,5 e-2	5,3 e-1	2,0 e-2
Methyl Parathion	298-00-0	2,0 e+3	1,9 e+3	1,1 e+3	8,5 e+1	1,1 e+3	6,8 e+1
Methyl Tert-Butyl Ether	1634-04-4	8,1 e-2	1,7 e-1	8,2 e-2	2,9 e-2	8,2 e-2	7,0 e-3

Methylacrylonitrile	126-98-7	4,6 e+2	6,9 e+2	5,4 e+2	6,3 e+3	4,7 e+2	4,0 e+2
Methylene Chloride	75-09-2	7,0 e+0	4,4 e+0	7,0 e+0	1,9 e-1	7,0 e+0	1,6 e-1
Methyl-Mercury	22967-92-6	1,9 e+5	1,2 e+5	1,9 e+5	2,1 e+5	1,6 e+5	1,5 e+5
Metolachlor	51218-45-2	4,6 e+0	9,5 e-1	7,2 e-1	7,7 e-1	6,9 e-1	5,8 e-1
Metribuzin	21087-64-9	8,0 e+0	9,0 e+0	8,0 e+0	2,4 e+0	8,0 e+0	3,7 e-1
Mevinphos	7786-34-7	1,1 e+3	5,1 e+1	4,2 e+0	9,0 e+0	4,2 e+0	7,5 e+0
Mirex	2385-85-5	2,3 e+4	2,6 e+5	1,7 e+4	1,8 e+4	1,6 e+4	1,0 e+4
Molybdenum	7439-98-7	1,2 e+4	3,6 e+3	1,4 e+4	2,0 e+4	2,2 e+3	1,4 e+3
Naphthalene	91-20-3	1,8 e+1	2,2 e+1	1,8 e+1	3,1 e+1	1,7 e+1	1,2 e+1
Nickel	7440-02-0	3,2 e+3	2,6 e+1	2,4 e+1	1,8 e+1	1,6 e+1	3,4 e+0
Nickel Compounds	NDB000	3,2 e+3	2,6 e+1	2,4 e+1	1,8 e+1	1,6 e+1	3,4 e+0
Nitric Acid	7697-37-2	4,2 e+0					
Nitrobenzene	98-95-3	2,4 e+1	1,1 e+2	3,4 e+1	4,0 e+1	3,2 e+1	5,5 e+0
Nitrogen Dioxide (NO2)	10102-44-0	4,3 e+0	1,4 e-2	9,5 e-3	7,0 e-17	9,5 e-3	6,1 e-17
Nitroglycerin	55-63-0	3,2 e+0	3,3 e-1	7,2 e-2	9,3 e-2	7,1 e-2	7,3 e-2
No2	10102-44-0	4,3 e+0					
O-Anisidine	90-04-0	1,8 e+2	2,3 e+1	8,4 e+1	6,4 e+1	8,2 e+1	4,6 e+1
O-Cresol(2)	95-48-7	1,5 e+1	4,9 e-1	3,1 e+0	2,5 e-1	3,1 e+0	2,4 e-1
Oxamyl	23135-22-0	2,0 e+1	6,9 e-1	4,4 e-1	2,2 e-1	4,3 e-1	1,3 e-1
Oxydemeton Methyl	301-12-2	1,0 e+3	1,7 e+2	3,1 e+1	2,2 e-1	3,1 e+1	2,1 e-1
Ozone	10028-15-6	4,4 e+0					
Parathion	56-38-2	1,0 e+2	3,1 e+1	7,9 e-1	6,0 e+0	7,3 e-1	1,9 e+0
Pcb-1254	11097-69-1	2,0 e+6	5,9 e+6	1,8 e+6	4,1 e+6	1,1 e+6	1,1 e+6
P-Chloroaniline	106-47-8	1,2 e+1	4,5 e+0	2,1 e+0	6,3 e-1	2,0 e+0	3,9 e-1
P-Cresol	106-44-5	1,6 e+1	5,0 e-2	6,9 e-1	3,2 e-2	6,9 e-1	2,4 e-2
Pentachlorobenzene	608-93-5	7,7 e+3	1,2 e+4	7,6 e+3	6,2 e+3	7,6 e+3	5,7 e+3
Pentachloronitrobenzene	82-68-8	1,3 e+3	1,4 e+3	1,0 e+3	9,5 e+2	1,0 e+3	8,5 e+2
Pentachlorophenol	87-86-5	3,2 e+1	1,3 e-1	7,6 e+0	2,1 e+1	4,8 e+0	2,0 e-1
Permethrin	52645-53-1	2,8 e+1	4,8 e+1	4,7 e-1	1,6 e+1	2,7 e-1	1,6 e-2
Phenol	108-95-2	3,6 e-1	2,7 e-3	7,5 e-2	2,8 e-3	7,5 e-2	2,6 e-3
Phosphoric Acid	7664-38-2	3,1 e+1					
Phoxim	14816-18-3	7,8 e+1	6,1 e+1	6,4 e+1	6,4 e+0	6,3 e+1	1,4 e+0
Phthalic Anhydride	85-44-9	5,9 e+0	4,3 e-5	8,4 e-4	7,7 e-2	8,4 e-4	7,7 e-2
Pirimicarb	23103-98-2	1,9 e+1	1,2 e-1	1,6 e+0	8,1 e+0	1,4 e+0	7,0 e+0
Pm10	EDF-077	2,9 e+0					
Pm2.5	EDF-213	3,3 e+1					
P-Phenylenediamine	106-50-3	1,4 e+0	2,7 e-2	3,1 e-2	4,7 e-2	2,9 e-2	3,1 e-2
Pronamide	23950-58-5	1,1 e+1	9,0 e+0	4,4 e+0	2,3 e+0	4,3 e+0	1,3 e+0
Propachlor	1918-16-7	3,6 e+1	1,6 e+0	6,1 e-1	1,1 e+0	6,1 e-1	1,1 e+0
Propylene (Propene)	115-07-1	2,2 e-2	3,7 e-2	2,2 e-2	1,2 e-2	2,2 e-2	2,4 e-4
Propylene Oxide	75-56-9	2,9 e+1	1,8 e+1	2,8 e+1	8,0 e-1	2,8 e+1	5,1 e-1
Pyrazophos	13457-18-6	1,4 e+2	4,0 e+1	5,9 e+0	1,7 e+1	5,3 e+0	5,5 e+0
Pyrene	129-00-0	1,1 e+1	2,4 e-1	1,4 e+1	4,2 e+1	4,7 e+0	4,2 e+0
Pyridine	110-86-1	7,4 e+1	8,0 e+0	4,7 e+1	9,0 e-1	4,7 e+1	7,2 e-1
S,S,S-Tributyltrithiophosphate	78-48-8	2,4 e+4	9,7 e+4	1,9 e+4	3,7 e+2	1,9 e+4	3,4 e+2
Sec-Butyl Alcohol	78-92-2	5,7 e-1	1,4 e-1	2,3 e-1	8,0 e-3	2,3 e-1	6,2 e-3
Selenium	7782-49-2	8,1 e+3	1,6 e+3	1,9 e+3	2,9 e+3	1,4 e+3	1,2 e+2
Selenium Compounds	SBP500	8,1 e+3	1,6 e+3	1,9 e+3	2,9 e+3	1,4 e+3	1,2 e+2
Silver	7440-22-4	1,6 e+3	4,6 e+2	1,4 e+3	1,8 e+3	2,6 e+2	1,4 e+2
Silver Compounds	SDO000	1,6 e+3	4,6 e+2	1,4 e+3	1,8 e+3	2,6 e+2	1,4 e+2
Silvex (Ni)	93-72-1	6,6 e+0	2,0 e+0	3,5 e+0	2,3 e+0	3,4 e+0	5,6 e-1
Simazine	122-34-9	1,0 e+2	1,1 e+1	1,2 e+1	2,6 e+1	1,1 e+1	2,4 e+1
Styrene	100-42-5	8,5 e-2	3,4 e-1	8,6 e-2	2,0 e-1	8,5 e-2	2,8 e-2
Styrene Oxide	96-09-3	3,0 e+1	5,4 e+0	6,5 e+0	7,2 e-1	6,5 e+0	4,7 e-1
Sulfate(1)	EDF-078	9,8 e+0					
Sulphur Dioxide (SO2)	2025884	6,0 e+0	6,4 e-4	5,1 e-4	7,3 e-3	4,4 e-4	2,5 e-4
Tert-Butyl Alcohol	75-65-0	2,2 e+0	2,2 e+0	1,9 e+0	6,2 e-1	1,9 e+0	3,6 e-1
Tetrachloroethylene	127-18-4	5,7 e+1	4,3 e+1	5,7 e+1	3,9 e+1	5,7 e+1	2,3 e+1
Thallium	7440-28-0	1,2 e+7	2,7 e+6	1,4 e+7	2,1 e+7	2,0 e+6	1,4 e+6
Thiram	137-26-8	5,0 e+1	1,3 e+0	3,9 e+0	3,4 e+0	3,8 e+0	3,0 e+0
Tin	7440-31-5	3,9 e+1	2,4 e-2	3,9 e+1	6,7 e+1	9,0 e-1	8,0 e-1
Tolclophos-Methyl	57018-04-9	2,2 e+1	1,9 e+1	6,9 e+0	4,6 e+0	6,5 e+0	6,0 e-1
Toluene	108-88-3	1,0 e+0	8,8 e-1	1,0 e+0	9,6 e-2	1,0 e+0	3,0 e-2

Toxaphene	8001-35-2	2,3 e+3	2,8 e+3	2,3 e+3	4,6 e+3	2,3 e+3	2,1 e+3
Trans-1,2-Dichloroethylene	156-60-5	6,6 e-1	2,4 e+0	6,7 e-1	6,4 e-1	6,7 e-1	4,4 e-2
Trans-1,3-Dichloropropene	10061-02-6	1,1 e+1	5,0 e+1	1,1 e+1	3,5 e-1	1,1 e+1	3,1 e-2
Triallate	2303-17-5	2,5 e+2	7,1 e+2	2,0 e+2	3,3 e+1	2,0 e+2	1,6 e+1
Triazophos	24017-47-8	6,7 e+2	3,0 e+2	1,8 e+2	1,2 e+2	1,7 e+2	7,2 e+1
Trichlorfon	52-68-6	1,7 e+2	6,6 e+0	3,9 e+0	3,7 e+0	3,8 e+0	3,3 e+0
Trichloroethylene	79-01-6	6,4 e-1	1,0 e+1	6,8 e-1	9,2 e+0	6,6 e-1	2,5 e-1
Triethylamine	121-44-8	1,1 e+1	1,1 e+0	4,9 e+0	4,3 e-2	4,9 e+0	1,9 e-2
Trifluralin	1582-09-8	1,1 e+2	8,6 e+0	7,9 e+1	1,5 e+2	6,8 e+1	3,1 e+1
Triphenyltin Chloride	639-58-7	1,3 e+3	5,8 e+2	8,3 e+1	4,8 e+2	6,1 e+1	8,0 e+1
Vanadium (Fume Or Dust)	7440-62-2	1,2 e+3	7,1 e+2	9,7 e+2	1,2 e+3	4,0 e+2	1,2 e+2
Vinyl Acetate	108-05-4	1,5 e+0	7,5 e-1	1,4 e+0	1,5 e-2	1,4 e+0	1,1 e-2
Vinyl Bromide	593-60-2	2,3 e+1	5,0 e+1	2,3 e+1	1,3 e+1	2,3 e+1	2,2 e+0
Vinyl Chloride	75-01-4	6,9 e+1	3,8 e+3	7,2 e+1	3,7 e+2	7,2 e+1	4,1 e+0
Xylenes (Total)	1330-20-7	2,7 e-1	3,1 e-1	2,7 e-1	3,4 e-2	2,7 e-1	7,8 e-3
Zinc	7440-66-6	1,9 e+2	1,4 e+1	1,8 e+1	2,2 e+1	8,2 e+0	1,8 e+0
Zinc Compounds	ZFS000	1,9 e+2	1,4 e+1	1,8 e+1	2,2 e+1	8,2 e+0	1,8 e+0
Zineb	12122-67-7	6,6 e+0	1,8 e+0	6,7 e-1	8,7 e-1	6,6 e-1	7,8 e-1

Table 4: Cancer human toxicity potential values for emissions to different compartments, in benzene-to-air equivalents.

Chemical Name	CAS Number	Air	Surface Water	Surface Soil agri	Root zone soil agri	Surface soil non-agricultural	Root zone soil non-agricultural
1,1,1,2-tetrachlorroethane	630-20-6	3,2 e+0	2,8 e-1	3,1 e+0	2,5 e-1	3,1 e+0	2,2 e-1
1,1,2,2-tetrachloroethane	79-34-5	9,1 e+0	6,4 e+0	8,9 e+0	2,7 e+0	8,9 e+0	2,4 e+0
1,1,2-trichloroethane	79-00-5	2,2 e+0	2,4 e+0	2,2 e+0	1,4 e+0	2,2 e+0	7,9 e-1
1,1-dichloroethane	75-34-3	2,3 e-1	2,3 e-1	2,3 e-1	1,4 e-2	2,3 e-1	9,0 e-3
1,1-dichloroethylene	75-35-4	6,9 e-1	3,0 e+0	6,9 e-1	4,0 e-1	6,9 e-1	3,1 e-2
1,1-dimethylhydrazine	57-14-7	7,2 e+0	5,4 e-1	5,3 e-1	6,4 e-2	5,3 e-1	1,6 e-2
1,2,3,4,6,7,8-heptachlorodibenzofuran	67562-39-4	6,9 e+5	3,6 e+6	5,5 e+5	1,8 e+6	1,0 e+5	1,0 e+5
1,2,4-trichlorobenzene	120-82-1	4,5 e-3	1,8 e-1	6,3 e-3	4,1 e-2	5,4 e-3	2,0 e-3
1,2-dibromoethane	106-93-4	6,3 e+0	1,2 e+1	6,4 e+0	1,8 e+0	6,4 e+0	6,4 e-1
1,2-dichloroethane	107-06-2	2,4 e+0	2,8 e+0	2,4 e+0	3,2 e-1	2,4 e+0	2,2 e-1
1,2-dichloropropane	78-87-5	1,1 e+0	1,4 e+0	1,1 e+0	1,3 e+0	1,1 e+0	4,4 e-1
1,3-butadiene	106-99-0	5,4 e-1	4,9 e+0	5,4 e-1	1,4 e-1	5,4 e-1	1,8 e-3
1,3-dichlorobenzene	541-73-1	6,0 e-1	8,3 e-1	5,9 e-1	1,7 e-1	5,9 e-1	1,0 e-1
1,3-dichloropropene	542-75-6	3,0 e-1	2,7 e-1	2,9 e-1	5,8 e-3	2,9 e-1	2,0 e-3
1,4-Dichlorobenzene (p)	106-46-7	1,4 e+0	7,2 e-1	1,4 e+0	1,4 e+0	1,4 e+0	1,0 e+0
1,4-dioxane	123-91-1	8,6 e-2	9,3 e-2	8,6 e-2	6,9 e-2	8,1 e-2	6,8 e-3
11,12-benzofluoranthene	207-08-9	1,0 e+3	1,5 e+4	1,1 e+3	1,3 e+3	1,0 e+3	8,1 e+2
1-chloro-2,3-epoxypropane	106-89-8	1,1 e+0	4,5 e-1	9,4 e-1	5,0 e-2	9,4 e-1	3,8 e-2
1-chloro-4-nitrobenzene	100-00-5	3,0 e+0	2,9 e+0	3,0 e+0	1,6 e+0	3,0 e+0	1,5 e+0
1-naphtyl n-methylcarbamate	63-25-2	3,5 e-3	3,6 e-2	3,7 e-3	5,1 e-3	3,6 e-3	3,6 e-4
2,3,4,7,8-pentachlorodibenzofuran	57117-31-4	8,5 e+6	4,0 e+7	3,8 e+6	1,7 e+7	1,4 e+6	1,3 e+6
2,3,7,8-tcdd	1746-01-6	1,2 e+9	7,0 e+8	1,2 e+9	9,0 e+9	2,0 e+8	2,0 e+8
2,3,7,8-tetrachlorodibenzofuran	51207-31-9	1,6 e+6	7,0 e+6	6,7 e+5	1,6 e+6	4,3 e+5	4,1 e+5
2,4,6-trichlorophenol	88-06-2	2,5 e+0	4,3 e-2	1,6 e+0	3,0 e-1	1,6 e+0	1,0 e-1
2,4,6-trinitrotoluene	118-96-7	5,6 e-1	3,2 e-3	4,8 e-2	1,8 e-1	4,5 e-2	1,6 e-1
2,4-d [acetic acid (2,4-dichlorophenoxy)-]	94-75-7	6,1 e-1	1,5 e-2	3,0 e-2	8,4 e-2	2,9 e-2	7,3 e-2
2,4-diaminotoluene	95-80-7	6,2 e+1	1,5 e+0	5,4 e+0	2,2 e+1	4,0 e+0	1,4 e+1
2,4-dinitrotoluene	121-14-2	4,5 e+0	4,1 e-2	1,5 e+0	1,8 e+0	1,4 e+0	1,3 e+0
2,6-dinitrotoluene	606-20-2	1,0 e+1	4,6 e-2	1,8 e+0	4,5 e+0	1,7 e+0	3,4 e+0
2-aminonaphthalene	91-59-8	3,6 e+0	3,4 e+0	2,1 e+0	2,7 e-1	2,1 e+0	9,6 e-2
2-butenal	123-73-9	3,3 e+0	1,8 e+0	3,1 e+0	1,5 e-2	3,1 e+0	7,8 e-3
2-nitropropane	79-46-9	2,2 e+1	5,7 e+1	2,4 e+1	2,4 e+1	2,4 e+1	5,3 e+0
2-phenylphenol	90-43-7	7,2 e-4	2,0 e-3	6,2 e-4	2,6 e-4	6,1 e-4	8,4 e-6
3,3-dichlorobenzidine	91-94-1	9,6 e+0	2,7 e-3	2,9 e+0	2,1 e+1	9,2 e-1	5,7 e+0
4,4'-diamino ditan	101-77-9	2,2 e+1	4,4 e-1	1,4 e-1	8,8 e-1	1,4 e-1	8,3 e-1
4-aminobiphenyl	92-67-1	5,6 e+2	1,3 e+1	3,3 e+0	1,3 e+1	3,2 e+0	1,1 e+1
Acephate	30560-19-1	1,6 e-1	3,0 e-2	1,3 e-2	1,3 e-4	1,3 e-2	8,6 e-5
Acetaldehyde	75-07-0	1,7 e-2	6,8 e-3	1,5 e-2	4,1 e-5	1,5 e-2	2,4 e-5
Acetamide	60-35-5	9,1 e-1	1,9 e-2	4,8 e-2	3,7 e-3	4,8 e-2	4,2 e-4
Acrylamide	79-06-1	1,3 e+2	1,6 e+0	2,6 e-1	2,6 e-1	2,5 e-1	7,6 e-2
Acrylonitrile	107-13-1	3,9 e+0	1,6 e+0	3,7 e+0	1,5 e-1	3,7 e+0	6,4 e-2
Aldrin	309-00-2	2,5 e+3	9,2 e+3	3,3 e+3	7,9 e+3	1,9 e+3	1,7 e+3
Allyl chloride	107-05-1	3,8 e-2	2,0 e-2	3,8 e-2	2,9 e-3	3,8 e-2	2,9 e-4
Allyl trichloride	96-18-4	1,3 e+2	1,6 e+2	1,3 e+2	7,4 e+1	1,3 e+2	4,2 e+1
Alpha-HCH (alpha-BHC)	319-84-6	8,7 e+1	1,7 e+2	3,8 e+1	1,6 e+1	3,7 e+1	4,7 e+0
Aniline	62-53-3	1,1 e-2	6,8 e-3	6,1 e-3	4,4 e-4	6,1 e-3	2,3 e-4
Arsenic	7440-38-2	2,6 e+3	6,4 e+2	2,7 e+3	4,3 e+3	4,7 e+2	2,8 e+2
Arsenic compounds	ARF750	2,6 e+3	6,4 e+2	2,7 e+3	4,3 e+3	4,7 e+2	2,8 e+2
Atrazine	1912-24-9	9,7 e+0	8,6 e-3	1,9 e+0	1,1 e+1	1,3 e+0	7,2 e+0

Aziridine	151-56-4	3,4 e+2	8,1 e+2	4,6 e+2	1,5 e+1	4,6 e+2	5,0 e+0
Baygon	114-26-1	6,6 e-2	9,5 e-3	4,3 e-3	7,9 e-3	4,3 e-3	7,3 e-3
Benomyl	17804-35-2	1,0 e-1	6,2 e-3	5,3 e-3	3,8 e-2	4,8 e-3	3,3 e-2
Benzene	71-43-2	1,0 e+0	7,6 e-1	1,0 e+0	4,4 e-1	1,0 e+0	1,1 e-1
Benzidine	92-87-5	1,1 e+4	5,7 e+2	3,4 e+2	5,4 e+2	3,4 e+2	5,2 e+2
Benzo(a)anthracene	56-55-3	5,4 e+1	4,5 e-1	2,2 e+1	9,1 e+1	8,2 e+0	7,7 e+0
Benzo(a)pyrene	50-32-8	6,4 e+3	9,4 e+0	2,0 e+2	3,0 e+4	2,6 e+1	1,9 e+1
Benzo(b)fluoranthene	205-99-2	1,3 e+2	3,7 e+2	1,1 e+2	2,4 e+2	4,6 e+1	4,4 e+1
Benzo(b)pyridine	91-22-5	1,2 e+1	3,0 e+0	5,9 e+0	4,7 e-1	5,9 e+0	3,0 e-1
Benzoic trichloride (benzotrichloride)	98-07-7	2,4 e+2	1,9 e-2	6,9 e-1	6,1 e+0	6,9 e-1	6,0 e-1
Benzyl chloride	100-44-7	8,9 e-1	7,9 e-2	8,5 e-1	1,3 e-1	8,4 e-1	7,0 e-2
Beryllium	7440-41-7	2,2 e+1	6,1 e-47	4,5 e-2	2,0 e-2	2,7 e-2	1,3 e-2
Beryllium compounds	BFQ500	2,2 e+1	6,1 e-47	4,5 e-2	2,0 e-2	2,7 e-2	1,3 e-2
Beta-HCH (beta-BHC)	319-85-7	9,8 e+1	1,3 e+2	3,6 e+1	2,3 e+1	3,4 e+1	9,3 e+0
Bifenthrin	82657-04-3	3,9 e+0	1,1 e+1	9,5 e-1	1,1 e+1	4,5 e-1	1,8 e-1
Bis(2-chloro-1-methylethyl) ether	108-60-1	8,5 e-2	2,9 e-1	9,5 e-2	1,7 e-1	9,2 e-2	2,3 e-2
Bis(2-chloroethyl)ether	111-44-4	1,6 e+1	2,6 e+1	1,8 e+1	1,8 e+1	1,7 e+1	5,8 e+0
Bis(2-ethylhexyl)phthalate	117-81-7	1,3 e-1	3,5 e-2	1,2 e-3	2,0 e-2	1,0 e-3	1,7 e-4
Bromodichloromethane	75-27-4	5,2 e+1	3,9 e+1	5,1 e+1	1,3 e+1	5,1 e+1	1,3 e+1
Bromoform	75-25-2	1,1 e+0	1,2 e+0	1,1 e+0	3,8 e-1	1,1 e+0	3,4 e-1
Bromoxynil	1689-84-5	4,6 e+0	1,6 e+0	2,7 e-1	1,9 e-1	2,7 e-1	1,5 e-1
Cadmium	7440-43-9	2,8 e+1	1,3 e-49	8,1 e-1	8,1 e-1	4,8 e-1	4,8 e-1
Cadmium compounds	CAE750	2,8 e+1	1,3 e-49	8,1 e-1	8,1 e-1	4,8 e-1	4,8 e-1
Captafol	2425-06-1	4,8 e+0	3,9 e+0	1,1 e-1	1,3 e-1	1,1 e-1	6,7 e-2
Captan	133-06-2	5,1 e-3	7,8 e-5	3,0 e-3	1,7 e-3	2,9 e-3	5,5 e-4
Carbazole	86-74-8	1,8 e-2	2,0 e-1	3,4 e-4	2,2 e-4	3,4 e-4	2,2 e-6
Carbendazim	10605-21-7	1,3 e-1	4,3 e-2	3,7 e-2	5,5 e-2	3,5 e-2	4,8 e-2
Carbon tetrachloride	56-23-5	2,8 e+2	2,7 e+2	2,8 e+2	4,3 e+1	2,8 e+2	4,2 e+1
Catechol	120-80-9	1,4 e-1	2,5 e-3	1,9 e-3	2,6 e-3	1,9 e-3	2,2 e-3
Chlordane	57-74-9	2,5 e+2	6,4 e+2	3,1 e+2	4,2 e+2	2,6 e+2	2,5 e+2
Chlorodibromomethane	124-48-1	1,9 e+1	1,7 e+1	1,8 e+1	6,2 e+0	1,8 e+1	5,9 e+0
Chloroform	67-66-3	1,6 e+0	1,6 e+0	1,6 e+0	1,0 e-1	1,6 e+0	7,1 e-2
Chloromethyl methyl ether	107-30-2	1,2 e+1	2,2 e-3	1,2 e+1	8,1 e-1	1,2 e+1	3,2 e-1
Chlorothalonil	1897-45-6	4,9 e-2	2,0 e-3	4,6 e-3	5,8 e-3	4,5 e-3	3,9 e-3
Chromium	7440-47-3	1,3 e+2	3,2 e-46	5,0 e-1	2,6 e-1	3,0 e-1	1,7 e-1
Chromium compounds	CMJ500	1,3 e+2	3,2 e-46	5,0 e-1	2,6 e-1	3,0 e-1	1,7 e-1
Chrysene	218-01-9	5,1 e+0	7,8 e-1	1,2 e+0	2,1 e+1	1,7 e-1	1,3 e-1
Cis-1,3-dichloropropene	10061-01-5	7,4 e-1	6,3 e-1	7,4 e-1	6,3 e-3	7,4 e-1	2,1 e-3
Cyanazine	21725-46-2	3,2 e+1	6,9 e+0	4,9 e+0	2,6 e+0	4,9 e+0	2,5 e+0
Cypermethrin	52315-07-8	1,9 e+0	4,1 e-1	7,6 e-1	3,3 e+0	3,7 e-1	4,2 e-3
Cyromazine	66215-27-8	1,1 e-1	5,0 e-2	4,2 e-2	1,3 e-2	4,2 e-2	1,1 e-2
Ddd	72-54-8	3,5 e+2	2,3 e+3	3,4 e+2	3,7 e+2	3,2 e+2	3,0 e+2
Dde	72-55-9	2,4 e+2	3,4 e+2	2,5 e+2	3,2 e+2	2,0 e+2	1,9 e+2
Ddt	50-29-3	2,1 e+2	4,1 e+2	2,2 e+2	2,7 e+2	1,8 e+2	1,7 e+2
Ddvp (dichlorvos)	62-73-7	1,0 e+0	6,6 e-1	9,1 e-1	2,6 e-4	9,1 e-1	1,2 e-4
Dibenz(a,h)anthracene	53-70-3	3,0 e+2	1,7 e+3	3,0 e+2	3,8 e+3	6,6 e+1	5,4 e+1
Dichlorobenzene (mixed isomers)	25321-22-6	1,4 e+0	1,5 e+0	3,8 e-1	2,5 e-1	3,7 e-1	1,4 e-1
Dicofol	115-32-2	8,2 e+1	1,8 e+2	5,9 e+1	1,8 e+0	5,9 e+1	1,2 e+0
Dieldrin	60-57-1	7,5 e+3	2,7 e+4	8,6 e+3	9,4 e+3	7,5 e+3	4,4 e+3
Diethyl sulfate	64-67-5	1,6 e+0	2,2 e-2	6,7 e-1	2,7 e-1	6,6 e-1	9,1 e-2
Dimethyl sulfate	77-78-1	1,9 e+2	2,2 e-1	3,4 e+1	4,7 e+0	3,4 e+1	4,5 e+0
Diuron	330-54-1	1,1 e+0	3,4 e-1	3,1 e-1	7,6 e-1	2,8 e-1	5,8 e-1
Ethoprop	13194-48-4	3,1 e+0	2,9 e+0	1,9 e+0	1,7 e-1	1,9 e+0	1,2 e-1
Ethyl acrylate	140-88-5	7,8 e-2	3,4 e-2	7,4 e-2	1,6 e-3	7,4 e-2	6,7 e-4
Ethylene oxide	75-21-8	1,1 e+1	5,6 e+0	1,0 e+1	1,7 e+0	1,0 e+1	8,6 e-1
Ethylenethiourea	96-45-7	1,2 e+0	1,0 e-1	7,5 e-2	3,5 e-2	7,2 e-2	1,2 e-2
Folpet	133-07-3	1,4 e-1	6,0 e-4	2,4 e-3	1,3 e-2	1,9 e-3	5,6 e-3
Formaldehyde	50-00-0	2,0 e-2	3,5 e-4	5,5 e-3	1,4 e-4	5,5 e-3	1,4 e-4
Gamma-HCH (lindane)	58-89-9	5,5 e+1	1,2 e+2	5,0 e+1	2,2 e+1	4,8 e+1	1,1 e+1

Glyphosate	1071-83-6	8,0 e-3	5,8 e-2	6,5 e-3	2,8 e-3	6,3 e-3	4,4 e-4
Heptachlor	76-44-8	3,8 e+1	2,7 e+2	7,8 e+1	2,9 e+2	4,3 e+1	3,0 e+1
Heptachlor epoxide	1024-57-3	4,5 e+1	1,8 e+3	5,6 e+1	1,0 e+2	4,8 e+1	4,5 e+1
Hexachlorinated dibenzofuran, 1,2,3,4,7,8-	70648-26-9	5,2 e+8	4,6 e+8	5,1 e+8	5,2 e+8	4,9 e+8	4,9 e+8
Hexachloro-1,3-butadiene	87-68-3	5,0 e+1	7,4 e+1	4,9 e+1	4,7 e+1	4,9 e+1	4,7 e+1
Hexachlorobenzene	118-74-1	2,3 e+3	3,4 e+3	2,2 e+3	2,1 e+3	2,2 e+3	2,1 e+3
Hexachloroethane	67-72-1	2,7 e+2	2,3 e+2	2,5 e+2	1,4 e+2	2,5 e+2	1,4 e+2
Hydrazine	302-01-2	2,2 e+1	2,5 e+0	5,2 e+0	9,0 e-3	5,2 e+0	3,0 e-3
Hydroquinone	123-31-9	1,2 e+0	2,5 e-4	2,3 e-3	1,8 e-2	2,1 e-3	1,7 e-2
Indeno(1,2,3-c,d)pyrene	193-39-5	2,8 e+2	5,7 e+3	3,5 e+2	5,1 e+3	1,4 e+2	1,2 e+2
Iprodione	36734-19-7	1,9 e+0	6,2 e-2	6,6 e-2	2,5 e-1	5,9 e-2	1,9 e-1
Isophorone	78-59-1	1,1 e-3	2,7 e-3	1,4 e-3	2,8 e-4	1,4 e-3	7,7 e-5
Kepone	143-50-0	6,2 e+3	8,4 e+4	5,0 e+3	5,1 e+3	4,9 e+3	3,0 e+3
Lead	7439-92-1	2,8 e+1	2,0 e+0	2,6 e+1	7,8 e+2	2,4 e+0	2,4 e+0
Lead compounds	LCT000	2,8 e+1	2,0 e+0	2,6 e+1	7,8 e+2	2,4 e+0	2,4 e+0
Linuron	330-55-2	7,5 e+0	5,4 e+0	2,4 e+0	2,0 e+0	2,3 e+0	1,5 e+0
Malathion	121-75-5	5,0 e-2	1,6 e-2	6,5 e-4	5,9 e-3	6,3 e-4	4,8 e-3
Methyl chloride	74-87-3	6,7 e-1	4,0 e-1	6,7 e-1	2,3 e-3	6,7 e-1	1,9 e-3
Methyl hydrzine	60-34-4	1,8 e+0	2,9 e+0	2,0 e+0	3,4 e-1	2,0 e+0	5,8 e-3
Methyl iodide	74-88-4	1,1 e+2	5,5 e+1	1,1 e+2	3,3 e+0	1,1 e+2	2,7 e+0
Methyl tert-butyl ether	1634-04-4	1,1 e-5	2,9 e-3	5,5 e-5	5,7 e-4	5,1 e-5	1,6 e-6
Methylene chloride	75-09-2	2,0 e-1	1,4 e-1	2,0 e-1	6,0 e-3	2,0 e-1	4,6 e-3
Metolachlor	51218-45-2	4,6 e-1	9,4 e-2	7,1 e-2	7,6 e-2	6,8 e-2	5,7 e-2
Mirex	2385-85-5	5,9 e+3	6,8 e+4	4,3 e+3	4,8 e+3	4,1 e+3	2,7 e+3
N,N'-bianiline	122-66-7	3,3 e+1	3,4 e+0	4,6 e-2	2,6 e-1	4,6 e-2	7,9 e-2
Nickel	7440-02-0	2,8 e+0	9,0 e-48	1,1 e-3	2,9 e-4	6,8 e-4	1,9 e-4
Nickel compounds	NDB000	2,8 e+0	9,0 e-48	1,1 e-3	2,9 e-4	6,8 e-4	1,9 e-4
Nitroglycerin	55-63-0	1,5 e+1	1,5 e+0	3,3 e-1	4,2 e-1	3,3 e-1	3,3 e-1
N-nitrosodiphenylamine	86-30-6	1,9 e-2	1,2 e-1	2,0 e-2	9,0 e-3	2,0 e-2	1,4 e-3
O-anisidine	90-04-0	1,3 e-1	1,1 e-1	1,3 e-1	2,0 e-1	1,1 e-1	3,7 e-2
O-toluidine	95-53-4	1,2 e-1	1,1 e-1	1,2 e-1	3,6 e-1	1,2 e-1	1,5 e-3
P-chloroaniline	106-47-8	2,3 e-1	8,3 e-2	3,8 e-2	1,2 e-2	3,8 e-2	7,2 e-3
Pentachloronitrobenzene	82-68-8	7,6 e+1	7,7 e+1	5,7 e+1	5,3 e+1	5,7 e+1	4,8 e+1
Pentachlorophenol	87-86-5	1,2 e+0	5,0 e-3	3,0 e-1	8,2 e-1	1,9 e-1	7,6 e-3
Permethrin	52645-53-1	1,0 e+0	1,7 e+0	1,7 e-2	6,0 e-1	1,0 e-2	6,0 e-4
Pronamide	23950-58-5	9,6 e-1	7,5 e-1	3,7 e-1	1,9 e-1	3,6 e-1	1,1 e-1
Propylene oxide	75-56-9	2,6 e-1	4,2 e-1	2,6 e-1	4,2 e-2	2,6 e-1	4,7 e-3
P-toluidine	106-49-0	3,8 e-1	1,9 e+0	1,3 e+0	5,1 e+0	8,9 e-1	3,7 e-1
S,s,s-tributyltrithiophosphate	78-48-8	1,2 e+1	5,0 e+1	9,9 e+0	1,9 e-1	9,9 e+0	1,7 e-1
Safrole	94-59-7	3,1 e-1	1,8 e+0	3,5 e-1	2,3 e-1	3,3 e-1	1,5 e-2
Simazine	122-34-9	4,5 e+0	4,8 e-1	5,1 e-1	1,1 e+0	5,0 e-1	1,0 e+0
Styrene oxide	96-09-3	5,9 e-1	1,1 e-1	1,3 e-1	1,4 e-2	1,3 e-1	9,3 e-3
Tetrachloroethylene	127-18-4	9,2 e-1	7,9 e-1	9,2 e-1	7,3 e-1	9,2 e-1	3,7 e-1
Thiourea	62-56-6	2,3 e+0	1,9 e-2	1,4 e-2	6,0 e-3	1,3 e-2	2,1 e-3
Toxaphene	8001-35-2	5,0 e+1	6,0 e+1	5,0 e+1	1,0 e+2	4,9 e+1	4,6 e+1
Trans-1,3-dichloropropene	10061-02-6	5,6 e-1	5,6 e-1	5,6 e-1	5,8 e-3	5,6 e-1	1,6 e-3
Triallate	2303-17-5	1,7 e+1	4,8 e+1	1,3 e+1	2,2 e+0	1,3 e+1	1,1 e+0
Trichloroethylene	79-01-6	5,5 e-2	1,5 e-1	5,5 e-2	1,5 e-1	5,5 e-2	2,1 e-2
Trifluralin	1582-09-8	4,6 e-1	3,6 e-2	3,3 e-1	6,1 e-1	2,8 e-1	1,3 e-1
Vinyl bromide	593-60-2	3,6 e-1	8,0 e-1	3,6 e-1	2,0 e-1	3,6 e-1	3,5 e-2
Vinyl chloride	75-01-4	1,9 e+0	4,6 e+0	1,9 e+0	8,8 e-1	1,9 e+0	1,1 e-1

Literature used

Bare, J. 2002. *Traci - tool for the reduction and assessment of chemical and other environmental impacts*. Cincinnati: US EPA.

Bare, J. C., G. Norris, D. W. Pennington, and T. McKone. 2003. Traci - the tool for the reduction and assessment of chemical and other environmental impacts. *J. Ind. Ecol.* 6 (3-4):49-78.

CalEPA. 1994. *Criteria for carcinogens*. Sacramento: California Environmental Protection Agency, Office of Environmental Health Hazard Assessment.

Capaldo, K. P., C. Pilinis, and S. N. Pandis. 2000. A computationally efficient hybrid approach for dynamic gas/aerosol transfer in air quality models. *Atmos. Environ.* 34 (21):3617-3627.

Fenner, K., M. Scheringer, and K. Hungerbühler. 2000. Persistence of parent compounds and transformation products in a level iv multimedia model. *Environ. Sci. Technol.* 34 (17):3809-3817.

Goedkoop, M., and R. Spriensma. 1999. *The eco-indicator 99*. Amersfoort: PRe Consultants.

Guinée, J., and R. Heijungs. 1993. A proposal for the classification of toxic substances within the framework of life cycle assessment of products. *Chemosphere* 26 (10):1925-1944.

Hertwich, E. G. 2001. Intermittent rainfall in dynamic multimedia fate modeling. *Environ. Sci. Technol.* 35 (5):936-940.

Hertwich, E. G., O. Jolliet, D. Pennington, M. Hauschild, C. Schulze, W. Krewitt, and M. Huijbregts. 2002. Fate and exposure assessment in the life cycle impact assessment of toxic chemicals. In *Life cycle impact assessment: Striving towards best practice*edited by H. A. Udo de Haes. Pensacola: Society of Environmental Toxicology and Chemistry.

Hertwich, E. G., S. F. Mateles, W. S. Pease, and T. E. McKone. 2001. Human toxicity potentials for life cycle assessment and toxics release inventory risk screening. *Environ. Toxicol. Chem.* 20 (4):928–939.

Hertwich, E. G., and T. E. McKone. 2001. The spatial scale of pollutants in multimedia models and its implications for the potential dose. *Environ. Sci. Technol.* 35 (1):142-148.

Hertwich, E. G., T. E. McKone, and W. S. Pease. 1999. Parameter uncertainty and variability in evaluative fate and exposure models. *Risk Anal.* 19 (6):1193-1204.

———. 2000. A systematic uncertainty analysis of an evaluative fate and exposure model. *Risk Anal.* 20 (4):437-452.

Hertwich, E. G., W. S. Pease, and C. P. Koshland. 1997. Evaluating the environmental impact of products and production processes: A comparison of six methods. *Sci. Total Environ.* 196:13-29.

Huijbregts, M. A. J., U. Thissen, J. B. Guinee, T. Jager, D. Kalf, D. van de Meent, A. M. J. Ragas, A. Wegener Sleeswijk, and L. Reijnders. 2000. Priority assessment of toxic substances in lca i: Calculation of toxicity potentials for 181 substances. *Chemosphere* 41 (4):575-588.

Krewitt, W., A. Trukenmüller, T. M. Bachmann, and T. Heck. 2001. Country specific damage factors for air pollutants - a step towards site dependent life cycle impact assessment. *Int. J. Life Cycle Assess.* 4 (4):199-210.

Levy, J. I., J. K. Hammitt, Y. Yanagisawa, and J. D. Spengler. 1999. Development of a new damage function model for power plants: Methodology and applications. *Environ. Sci. Technol.* 33 (24):4364-4372.

Maddalena, R. L., T. E. McKone, D. W. Layton, and D. P. H. Hsieh. 1995. Comparison of multi-media transport and transformation models - regional fugacity model vs caltox. *Chemosphere* 30 (5):869-889.

McKone, T. E. 1993. *Caltox, a multimedia total exposure model for hazardous-waste sites*. UCRL-CR-111456PtI-IV. Livermore, CA: Lawrence Livermore National Laboratory.

McKone, T. E., and E. G. Hertwich. 2001. The human toxicity potential and a strategy for evaluating model performance in life cycle impact assessment. *Int. J. Life Cycle Assess.* 6 (2):106-109.

Bees 3.0(r) - building for environmental and economic sustainability. National Institute for Standards and Technology, Washington.

Schwartz, S. 1989. Acid deposition: Unraveling a regional phenomenon. *Sci* 243 (10 Feb):753-763.

Seinfeld, J. H., and S. N. Pandis. 1998. *Atmospheric chemistry and physics*. New York: J. Wiley.

Spadaro, J. V. 1999. Quantifying the damages of airborne pollution: Impact models, sensitivity analyses and applications. Ph.D. Dissertation, Centre d'Energétique, Ecole des Mines, Paris.

Spadaro, J. V., and A. Rabl. 1999. Estimates of real damage from air pollution: Site dependence and simple impact indices in lca. *Int. J. LCA* 4 (4):229-243.

Steen, B. 1999. *A systematic approach to environmental priority strategies in product development (eps). Version 2000 - general system characteristics*. CPM 1999:4. Gothenburg: Chalmers University.

U.S. EPA. 1998. *Integrated risk information system and health effects assessment summary tables. Electronic handbook of risk assessment values* (7(12)). Electronic Handbook Publishers, Redmond, WA. http://www.wolfenet.com/~sdwyer/hti.htm

http://toxnet.nlm.nih.gov/. 12/31/98.

Venkatram, A., B. E. Ley, and S. Y. Wong. 1982. A statistical model to estimate long-term concentrations of pollutants associated with long-range transport. *Atmos. Environ.* 16 (2):249-257.

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