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Accounting for Toxicity Risks in Pollution Control

Does It Matter?

Susmita Dasgupta
Benoît Laplante
Craig Meisner

It is important for environmental regulators to weight pollutants for their relative toxicity risk when developing priorities for pollution control efforts at the industrial or regional level. But at high levels of aggregation, the choice of indicator need not be the subject of immense debate.

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Summary findings

The accounting and public release of information about industrial toxic pollution emissions is meeting increasing criticism in that these listings typically do not account for the different toxicity risks associated with different pollutants. A firm emitting a large amount of a relatively harmless substance is ranked as a heavier polluter than a firm emitting a small quantity of a potent substance.

Such "unweighted" rankings of firms, it is argued, may lead to a misallocation of resources and a wrong prioritization of efforts in pollution control. This is a particular problem in developing countries, where sources for pollution control are typically scarce.

To account for varying toxicity risk, a number of organizations have developed thresholds or exposure limits for various pollutants. But many toxicity risk factors and methods are currently available, and different risk indicators yield different results and hence priorities.

So Dasgupta, Laplante, and Meisner review seven risk methods and construct 10 sets of toxicity risk factors from those indicators. They apply those factors to the 3,426 industrial municipalities of Brazil and explore Rio de Janeiro and São Paulo in detail.

After ranking states and municipalities for their pollution intensity, results indicate that at the *state* level, risk-weighted rankings remain largely the same across the 10 sets of toxicity risk factors used in this paper. By and large the result also holds true at the *municipal* level.

Although at the *state* level the unweighted ranking is relatively similar to the risk-weighted ranking, at the *municipal* level significant differences were found between the risk-weighted and unweighted rankings.

These findings suggest that it is important for environmental regulators to weight pollutants for their relative toxicity risk when developing priorities for pollution control efforts at the industrial or regional level. But at high levels of aggregation, the choice of indicator need not be the subject of immense debate.

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ACCOUNTING FOR TOXICITY RISKS IN POLLUTION CONTROL: DOES IT MATTER?

By

Susmita Dasgupta
Benoit Laplante
and
Craig Meisner

The World Bank
Development Research Group
Environment & Infrastructure

For correspondence, communicate with: Susmita Dasgupta, Development Research Group, The World Bank, 1818 H Street, N.W., Washington, D.C. 20433; or at sdasgupta@worldbank.org.

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Executive Summary

The accounting and public release of information pertaining to industrial toxic pollution emissions is meeting increasing criticism in that these listings typically do not account for the different toxicity risks associated with different pollutants: A firm emitting a large quantity of a relatively harmless substance would rank as a larger polluter than another firm emitting a small quantity of a very potent substance. It is argued that such "unweighted" rankings of firms may lead to a misallocation of resources and wrong prioritization of effort devoted to pollution control. This may be of particular importance for developing countries where resources devoted to pollution control are typically scarce.

In an attempt to account for the relative differences in chemical toxicity, a number of organizations have developed thresholds or exposure limits for various pollutants to account for their various toxicity risk. Given the large number of toxicity risk factors and methodologies currently available, a crucial issue pertains to the possibility that different risk indicators may yield different results, thus leading to different sets of priorities. In this paper, we review seven risk methodologies currently available, and construct 10 different sets of toxicity risk factors from these indicators. We then apply these factors to the 3426 industrialized municipals of Brazil; we further explore in more detail, the case of Rio de Janeiro and São Paulo. Upon ranking states and municipals for their pollution intensity, results indicate that at the *state* level, risk weighted rankings remain largely the same across the 10 different sets of toxicity risk factors used in this paper. This result by and large also holds true at the *municipal* level. Moreover, at the *state* level, the unweighted ranking is relatively similar to the risk weighted ranking. However, at the *municipal* level, significant differences were found between the risk weighted and unweighted rankings.

These findings suggest that it is of importance for environmental regulators to engage into weighting pollutants for their relative toxicity risk when prioritizing pollution control effort either at the industrial or regional level. The findings however suggest that at high levels of aggregation, the choice of a particular indicator should not be a matter of immense debate.

I. Introduction

An increasing number of environmental regulators in developed and developing countries have embarked on programs to account for the release of toxic pollution by industrial firms. Some of these programs also involve the public release of the information thus collected from industrial polluters. An example of such a program is the Toxics Release Inventory (TRI) published annually by the United States Environmental Protection Agency. These listings are meeting an increasing amount of criticism in that they typically do not account for the different toxicity risk associated with different pollutants: A firm emitting a large quantity of a relatively harmless substance would rank higher than another firm emitting a small quantity of a very potent substance. It is argued that such "unweighted" rankings of firms may lead to a misallocation of resources and wrong prioritization of effort devoted to pollution control. To the extent that the information is publicly available, it may also lead to a false sense of security, or alarm. Indeed, results from previous applications of risk-weighting factors have been significantly different than priority rankings based solely on volume-based techniques which do not account for the heterogeneous risk of pollutants.[1]

Acknowledging these differences in chemical toxicity, a number of organizations have developed indices, based on alternative methodologies, to weigh pollutants to account for their relative toxicity risk. Given the large number of indicators currently

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[1] Among others, see Hettige and Wheeler (1996), Horvath et al. (1995), Laplante and Smits (1998) and Swanson et al. (1997).

available, a recurring concern and crucial issue for environmental regulators pertains to the possibility that different methodologies may yield different results, and indicate different sets of priorities. This may be of particular importance for environmental regulators of developing countries where resources devoted to pollution control are typically scarce.

In this paper, we review seven indicators currently available and from these construct ten different sets of toxicity risk factors. We then apply these toxicity risk factors to the 3426 industrialized municipals of Brazil,[2] and discuss in more detail the estimates obtained for São Paulo and Rio de Janeiro (henceforth Rio). Our findings suggest that it is of importance for environmental regulators to engage into weighing pollutants for their relative risk factors when prioritizing pollution control effort. The findings however suggest that the choice of a particular risk indicator should not be a matter of immense debate as the relative impact of different risk indicators appears to be small for the prioritization of pollution control effort at high levels of industrial aggregation.

In the next section, we describe the risk exposure indicators chosen for analysis in this paper, and for each index indicate how the relative risk factors were constructed. In Section III, we apply these factors to Brazil and focus more specifically on Rio and São

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[2] There were a total of 4974 municipals as of August 31, 1995; 3426 of these presented some degree of industrialization (IBGE, Directoria de Geociências, Departamento de Estudos Territoriais, 1995).

Paulo. We first provide a brief description of the Brazilian industrial and environmental regulatory contexts. We then estimate toxic pollution emissions for each industry and region of Brazil with the help of the *Industrial Pollution Projection System*. Finally, we apply the various sets of toxicity risk factors to these pollution estimates. We briefly conclude in Section IV.

II. Risk weighting methodologies and risk factors

(i) Risk weighting methodologies

In both developing and developed countries, risk assessment has recently become an integral component of the formulation of pollution regulation. In a context of limited resources, the identification and prioritization of intervention (defined in terms of industrial sectors or geographical areas) based on an assessment of risk is imperative for the reduction of toxic-related health problems. In the United States for example, various governmental and non-governmental organizations, such as the *Environmental Protection Agency* (EPA) and the *American Conference of Governmental Industrial Hygienists* (ACGIH) regularly publish comprehensive lists of hazardous chemicals which may serve as guidelines for explicitly incorporating toxic risk in the prioritization of pollution control effort. However, each of these organizations follows its own method of classifying chemical hazards or risk, where the choice of an indicator is for the most part dictated by regulatory requirements. For the purpose of the current comparative analysis, our interest lies not only in comparing risk-weighted and unweighted rankings of pollution intensive areas, but also to compare the risk weighted rankings under alternative measures of risk (such as short term vs long term exposure).

In Table 1, we list seven widely recognized toxicity indices along with the organization using these indices. The classification enforceable / non-enforceable indicates whether or not the index is enforceable by law.

Table 1
Toxicity indices

Source	Index name	Classification
American Conference of Governmental Industrial Hygienists (ACGIH)	Threshold Limit Values (TLV)	Medium-term Non-enforceable
U.S. Department of Labor, Occupational Safety and Health Administration (OSHA)	Permissible Exposure Limits PEL)	Medium-term Enforceable
National Institute for Occupational Safety and Health (NIOSH)	Recommended Exposure Limits (REL)	Medium-term Enforceable
Deutsche Forschungsgemeinschaft (DFG, Federal Republic of Germany)	Maximum Concentration Values in the Workplace (MAK)	Medium-term Enforceable
Santa Clara Center for Occupational Safety and Health (SCCOSH)	Health-Based Exposure Limits (HBEL)	Long-term Non-enforceable
U.S. Department of Energy, Subcommittee on Consequence Assessment and Protective Action (SCAPA)	Temporary Emergency Exposure Limits (TEEL)	Short-term Enforceable*
U.S. Environmental Protection Agency, Sector Facility Indexing Project (SFIP)	Toxics Release Inventory Indicators toxicity weights (TRI toxicity weights)	Long-term Non-enforceable

* TEEL are enforceable only on U.S. Department of Energy sites.

In Table 2, we provide a brief definition of each index. Note that TLV, PEL, REL, and MAK all have the same definition. However, while PEL, REL and MAK have all been largely adopted from TLV, the number of chemicals covered by each index is different. Moreover, PEL, REL and MAK are enforceable by law whereas TLV act only as recommendations. TLV, PEL, REL and MAK have been broadly classified as medium term since exposure is defined as a time-weighted average per working day and / or working week with the number of years of exposure not being explicitly referred to (i.e. versus chronic or lifetime exposure).

Two other indicators, HBEL and TEEL, are of interest as they define polar extremes of relative toxicity: HBEL are maximum lifetime daily exposure concentrations, while TEEL can be interpreted as maximum short term exposure concentrations. The last indicator, the U.S. EPA TRI toxicity weighting system, is a new initiative by the EPA to address public criticism that the TRI inventory has been purely based on volumes of emissions.[3] This very recent development of risk incorporation into the TRI accounting of chemical loads is a valuable opportunity for the purpose of the current exercise.

(ii) Risk factors

In order to incorporate risk into the analysis, we must aggregate the releases of various industrial pollutants within a specific region. In order to do so, we must initially convert each chemical into equivalent weights for each of the ten sets of toxicity indicators presented in Table 2. These weights were calculated by normalizing each chemical with respect to a reference chemical, chosen to be sulfuric acid:

$$(1) \qquad w_{ij} = \frac{\text{(Reference value for sulfuric acid provided by index j)}}{\text{(Reference value of chemical i provided by index j)}}$$

where w_{ij} is the sulfuric acid equivalent risk factor associated with chemical i upon using toxicity index j (j = 1 to 10).[4]

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[3] The TRI is understood as being one of the largest sources of environmental information available to the public (Hamilton, 1995; Konar and Cohen, 1997).

[4] For example, suppose there are three pollutants A, B, and C, with pollutant A representing sulfuric acid. Each of the 10 indices provides a threshold or exposure limit for pollutants A, B and C. Let the limits provided by index j be R_{Aj}, R_{Bj}, and R_{Cj} respectively. Then, w_{Aj} would be R_{Aj}/R_{Aj} or 1, w_{Bj} would be R_{Aj}/R_{Bj} and w_{Cj} would be R_{Aj}/R_{Cj}.

Let Q_{ix} be the estimated (unweighted) pollution load of chemical i in region x. Then,

$$Q_{ix} \bullet w_{ij} \tag{2}$$

gives the estimated risk weighted releases of pollutant i (in sulfuric acid equivalent) in region x upon using index j. Aggregating over all pollutants yields:

$$P_{xj} = \sum_{i=1}^{n} Q_{ix} \bullet w_{ij} \tag{3}$$

where P_{xj} is the estimated total risk weighted releases of pollution in region x upon using index j, and n is the number of chemicals covered by index j.

III. Estimates of risk weighted pollution load in Brazil

(i) The Brazilian context

The industrial sector in Brazil accounts presently for nearly 35% of GDP, and represents a significant share of the total working population, across the five major regions of Brazil (Table 3). However, the relative importance of industrial activity across Brazilian states varies considerably and in some regions represents a very significant share of total employment. As can be seen in Table 4, manufacturing employment as a percentage of the total working population is quite high in such states as São Paulo and Rio de Janeiro. These highly industrialized states (with the exception of the Distrito Federal) also enjoy a higher GDP per head while less industrialized states lag far behind (Table 5). Within the manufacturing sector, some the largest employers are in the wearing apparel, motor vehicle, metal and textile industrial sectors (Table 6).

Table 2
Description of index

Index	Description
1997 ACGIH Threshold Limit Values **(TLV)**	Time-weighted average (TWA) exposure concentration that cannot be exceeded for a conventional 8-hour workday and a 40-hour workweek.
1993-97 OSHA Permissible Exposure Limits **(PEL)**	TWA exposure concentration that cannot be exceeded for a conventional 8-hour workday and a 40-hour workweek.
1994 NIOSH Risk Exposure Limits **(REL)**	TWA exposure concentration that cannot be exceeded for a conventional 8-hour workday and a 40-hour workweek.
1996 DFG **(MAK)**	TWA exposure concentration that cannot be exceeded for a conventional 8-hour workday and a 40-hour workweek.
1995 SCCOSH Health-Based Exposure Limits **(HBEL – Non-Cancer)**	Maximum lifetime daily exposure concentration for a conventional 8-hour workday, 240-days/year, for 40 years.
1998 U.S. DOE SCAPA Temporary Emergency Exposure Limits **(TEEL-0)**	Derived mostly from TLV-STEL and PEL-STEL. A 15-minute time-weighted average exposure concentration that should not be exceeded at any time during the workday.
1998 U.S. DOE SCAPA Temporary Emergency Exposure Limits **(TEEL-1)**	Derived mostly from TLV-C and PEL-C. A time-weighted average concentration that is not to be exceeded during any part of the working exposure.
1998 U.S. DOE SCAPA Temporary Emergency Exposure Limits **(TEEL-2)**	Measure of *toxicity* (TCLo and TDLo) estimated from human or human-equivalent toxicity data from Sax's Dangerous Properties of Industrial Materials (1996/97) with a maximum of 500 mg/m^3 for particulate materials, if no hierarchy-based values could be estimated using methodology outlined in NIOSH (1994).
1998 U.S. DOE SCAPA Temporary Emergency Exposure Limits **(TEEL-3)**	Measure of *lethality* (LCLo, LDLo, and LD50) estimated from human or human-equivalent toxicity data from Sax's Dangerous Properties of Industrial Materials (1996/97) with a maximum of 500 mg/m^3 for particulate materials, if no hierarchy-based values could be estimated using methodology outlined in NIOSH (1994).
1998 U.S. EPA SFIP TRI Relative Risk-Based Chronic Human Health Indicator Toxicity Weights **(TRI Toxicity Weights)**	A chronic human health proportional weighting system utilizing Reference Dose values (RfD) for cancer and non-cancer effects, along with weight-of-evidence measures for carcinogens. RfDs are derived from a combination of NOAEL, LOAEL, uncertainty factors in intraspecies variability, interspecies extrapolation and extrapolation from subchronic to chronic data.

Note: STEL - Short-Term Exposure Limit; C - Ceiling limit; TCLo - Toxic Concentration Low; TDLo - Toxic Dose Low; LCLo - Lethal Concentration Low; LDLo - Lethal Dose Low; LD50 - Lethal Dose Fifty;* NOAEL - No Observable Adverse Effect Level; LOAEL - Lowest Observable Adverse Effect Level

* See Appendix A for more details on TCLo, TDLo, LCLo, LDLo and LD50.

Table 3: Industrial employment per region, 1993

Region	Total Working Population	Industrial Employment (1)	% Employed in Industry
Sudeste (2)	28 700 970	7 305 969	25.46
Sul (3)	11 560 445	2 535 344	21.93
Norte (4)	2 555 088	490 426	19.19
Centro-oeste (5)	4 601 976	704 640	15.31
Nordeste (6)	18 968 726	2 724 173	14.36

(1) - Industry includes the construction sector.
(2) - Sudeste includes: Minas Gerais, Espírito Santo, Rio de Janeiro, São Paulo.
(3) - Sul includes: Paraná, Santa Catarina, Rio Grande do Sul.
(4) - Norte includes: Rondônia, Acre, Amazonas, Roraima, Pará, Amapá, Tocantins.
(5) - Centro-oeste includes: Mato Grosso do Sul, Mato Grosso, Goiás, Distrito Federal.
(6) - Nordeste includes: Maranhão, Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe, Bahia.

Table 4: Level of manufacturing employment, 1994

State	Manufacturing Employment (1)	Population of Working Age (2)	% of Working Population in Manufacturing
Santa Catarina	313 259	2 757 602	11.36
São Paulo	2 082 706	19 789 464	10.52
Rio Grande do Sul	494 381	5 528 990	8.94
Paraná	273 241	4 784 951	5.71
Minas Gerais	421 575	9 000 056	4.68
Rio de Janeiro	364 493	7 783 014	4.68
Pernambuco	136 808	3 756 185	3.64
Alagoas	46 871	1 327 357	3.53
Espírito Santo	53 506	1 543 563	3.47
Amazonas	34 404	1 158 283	2.97
Ceará	93 484	3 330 191	2.81
Mato Grosso do Sul	24 346	1 057 585	2.30
Goiás	53 221	2 423 371	2.20
Rio Grande do Norte	28 175	1 320 106	2.13
Sergipe	16 414	814 387	2.02
Pará	47 986	2 749 896	1.75
Paraíba	25 075	1 607 131	1.56
Mato Grosso	16 757	1 322 892	1.27
Rondônia	9 351	760 053	1.23
Bahia	73 754	6 271 747	1.18
Distrito Federal	11 673	1 028 217	1.14
Piauí	12 685	1 302 481	0.97
Amapá	1 290	161 986	0.80
Acre	1 670	220 835	0.76
Maranhão	16 649	2 419 597	0.69
Tocantins	2 174	505 368	0.43
Roraima	386	156 300	0.25
Total	4 656 334	84 881 608	5.49

(1) - *Source: Instituto Brasileiro de Geografia e Estatísticsa (IBGE), 1994.*
(2) - Source: IBGE, Diretoria de Pesquisas, Departamento de População e Indicadores Sociais, Censos Demográficos de 1980 e 1991. Calculated as the total population between ages 17 to 60.

Table 5
Gross domestic product per capita, 1994

Highest	($)	Lowest	($)
Distrito Federal	7 080	Paraíba	1 108
São Paulo	4 666	Maranhão	1 055
Rio de Janeiro	4 386	Sergipe	958
Paraná	3 674	Tocantins	901
Rio Grande do Sul	3 670	Piauí	835

Source: Instituto de Pesquisa Económica Aplicada (IPEA).

Table 6
Top 10 manufacturing employers

Brazil		Rio de Janeiro		São Paulo	
Industry	**Percentage share***	**Industry**	**Percentage share**	**Industry**	**Percentage share**
Wearing apparel	7.75	Wearing apparel	12.07	Motor vehicles	10.57
Motor vehicles	6.51	Iron & steel	7.20	Wearing apparel	6.69
Footwear	5.01	Printing & publishing	7.04	Fabricated metal products	6.02
Fabricated metal products	4.44	Plastic products, N.E.C.	4.87	Plastic products, N.E.C.	4.84
Sugar factories & refineries	4.32	Drugs & medicines	4.26	Spinning, weaving & finishing textiles	4.01
Spinning, weaving & finishing textiles	4.14	Bakery products	4.07	Electrical apparatus & supplies, N.E.C.	3.93
Iron & steel	3.86	Fabricated metal products	4.03	Printing & publishing	3.59
Plastic products, N.E.C.	3.81	Shipbuilding & repairing	3.91	Sugar factories & refineries	3.12
Sawmills, planing & other wood mills	3.40	Spinning, weaving & finishing textiles	3.55	Footwear	3.02
Printing & publishing	3.39	Nonmetallic mineral products, N.E.C.	2.59	Iron & steel	2.76

* - Percentage share of all manufacturing employment.

An unfortunate consequence of industrialization is the increasing emission of toxics to the environment, and subsequently the requirement for prioritization, regulation and control. Brazil's experience with environmental regulation has been both a success story, due to the significant experience of some state agencies, and a failure as a consequence of recent fiscal constraints and a lack of political support.

Environmental legislation in Brazil dates back to 1973 and was modeled mostly after the American experience, relying heavily on standards and licenses. The objectives of environmental policy are defined in terms of minimum ambient environmental standards which the Federal Government has established for air and water. Brazil's pollution control policy is centralized around a licensing system that requires a valid environmental license for every potentially polluting activity. States have implemented their own licensing systems based on the national framework. Since 1974, most States have created Environmental Protection Agencies (OEMAS – *orgãos estaduais de meio ambiente*) which are in charge of licensing, monitoring and enforcing environmental regulations. States have implemented different systems of fines for environmental violations; fines are normally a function of the estimated level of damages resulting from the violation. However, as in most cases, the effective implementation of those fines has proved challenging.

Municipalities are playing an increasingly important role in pollution management and are currently responsible for zoning, water, sanitation, solid waste and drainage services. In addition, larger municipalities are assuming licensing functions for activities which have the potential of being significant sources of local pollution. However, the administrative capacity to implement, monitor and enforce the terms of the licenses is typically limited.

Pollution control in the states of Rio and São Paulo is the responsibility of FEEMA (*Fundacão Estadual de Engenharia do Meio Ambiente*) and CETESB (*Conpanhia de Tecnologica de Saneamento Ambiental*) respectively. These two agencies have often been acknowledged as leading environmental agencies in the developing world. They are the largest state environmental agencies in Brazil with staff of 2 200 and 900, and supported budgets of approximately US$ 90 and US$ 25 million for the year 1997 respectively (World Bank, 1998). Most other state environmental agencies have much smaller staff and budgets, and have suffered a serious decline in recent years due to fiscal constraints. The larger agencies have also experienced a serious decline in their effectiveness. Environmental management in the state of Rio has deteriorated as a result of the fiscal crisis and lack of political support under previous administrations. FEEMA is paralyzed by a lack of accountability, an excessive number of poorly paid and unmotivated staff, and serious budget rigidities. It is argued that the numerous bureaucratic environmental requirements, and a serious lack of reliable environmental information and planning prevent the State environmental agencies from adequately performing its core functions.

Given the poor economic and political environment within which state environmental agencies must operate, there is a strong need for the application of tested methodologies in order to prioritize pollution control effort. This is especially the case for state environmental agencies which are currently preparing comprehensive restructuring and modernization plans aimed at improving their effectiveness. These plans involve an important decentralization of roles and responsibilities, while still retaining a supervisory role. To these ends, the application of tested methodologies to estimate pollution load on a regional basis can provide regulators with crucial information pertaining to areas of high pollution intensity. This is especially the case on matters of toxic emissions for which information, on a plant and / or regional level, has never been thoroughly collected in Brazil.

(ii) Estimating pollution load in Brazil

As indicated earlier, in order to estimate the total releases of (sulfuric equivalent) chemicals in Brazil, we must first obtain (unweighted) estimates of emissions of chemicals (Q_{ix} in equation (2)). Despite the existing legislative and institutional apparatus, it is generally recognized that Brazilian environmental authorities (like most environmental authorities of developing countries) lack the necessary information on plant-level emissions to set priorities, strategies, and action plans. This is especially the case with toxic chemicals whose releases are typically not monitored.

As a response to this insufficiency of information, Hettige et al. (1995) have developed the *Industrial Pollution Projection System* (IPPS) to exploit the fact that industrial pollution is heavily affected by the scale of industrial activity and its sectoral composition. IPPS operates through sector estimates of pollution intensity (pollution per unit of activity). The system combines data from industrial activity (such as production and employment) with data on pollution emissions to calculate *pollution intensities*, i.e. the level of pollution emissions per unit of industrial activity (Pollution intensity = Pollution emissions / Measure of industrial activity). The model can be refined to include only *chemical intensities* by using information solely on chemical releases along with industrial activity (Chemical intensity = Chemical emissions / Measure of industrial activity).

As illustrated in Figure 1, chemical intensities have initially been calculated with data available in the United States from the U.S. Manufacturing Census and the U.S. Environmental Protection Agency (EPA). The Census maintains a database known as the Longitudinal Research Database (LRD) which contains information from the Census of Manufactures (CM) and the Annual Survey of Manufactures (ASM). While the CM contains information on all manufacturing establishments in the United States, the ASM seeks further and more detailed information on a subset of those companies. Once an establishment has been selected to be part of the ASM, information is collected from the chosen company once a year, for a period of 5 years. The LRD thus contains detailed information on approximately 200,000 plants. The EPA maintains a number of databases on pollution emissions including the Toxics Release Inventory (TRI), which was used to calculate chemical intensities for each industry.[5]

An immediate difficulty with the calculation of intensities is the measure of industrial activity. While physical volume of output would be the ideal unit of measurement, industries and even establishments within a given industry use different units to report the volume of their production, thus not allowing for comparison across industries. The value of output and plant-level employment (also contained in the LRD) however do offer such common units of measurement. Combining the LRD's database with the EPA TRI database, it was possible to calculate 329 chemical intensities for each industrial sector (at the 4 digit International Standard Industrial Classification (ISIC) level), using both the value of output and plant-level employment.[6]

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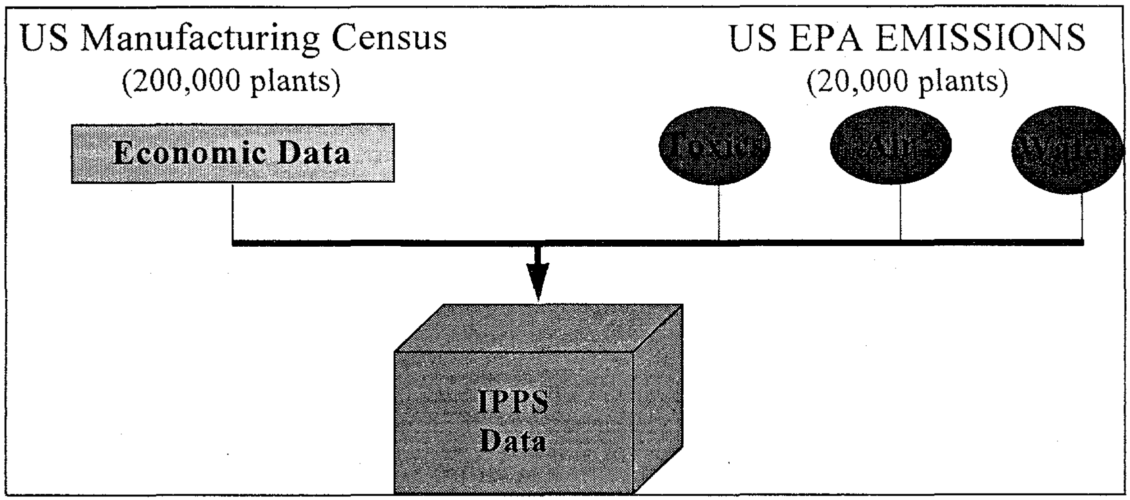
[5] At the time, the TRI contained information on annual emissions for more than 300 toxic chemicals to the environment. Manufacturing establishments that (1) employed 10 full-time employees or more and (2) produced, imported or processed 25,000 pounds or more of any listed chemical had to report the nature and quantity of the chemical produced, imported, or processed. In 1987, approximately 20,000 enterprises reported their releases of such chemicals. A listing of the 329 selected chemicals is provided in Appendix B.

[6] It should be understood that since different industries will emit a different number and composition of chemicals, each industry will have a different number of estimated chemical intensities. These intensities may be obtained from the web site http://www.worldbank.org/nipr

Figure 1
Industrial Pollution Projection System
Pollution Intensity



Source: Policy Research Department, The World Bank

For Brazil, we were able to obtain 1994 employment figures for every industrial sector, for all 3426 industrialized municipals. Multiplying these figures by the associated employment-based chemical intensity obtained from IPPS resulted in the total chemical load per industrial sector per municipal (or state).[7] Summing across all industries in a state or municipal yielded the estimated releases of chemicals in the state or municipality. In what follows, these estimates, *unweighted* for toxicity risk, are referred to as the "volume" ranking (or Q_{ix} in equation 2) since it is solely based on the total volume of releases, with no account of relative risk. These estimates can finally be weighted for

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[7] While absolute estimates of pollution emissions differ upon using employment-based pollution intensities and value-based pollution intensities, Hettige et al. (1995) and Laplante and Smits (1998) have shown that the *ranking* of industrial sectors (from largest polluters to smallest) remains the same. Moreover, Wheeler et al. (1998) in a comparative analysis of 12 countries, including Brazil, have found the ratio (Pollution emission / Employment) to be relatively constant across countries for the same industrial sectors.

their relative toxicity as shown previously (multiplied by w_{ij}). Results are presented for each of the 10 indices shown in Table 2.

(iii) Pollution load in Brazil

We first begin at the aggregate level, looking at pollution emissions at the state level for the entire country. In Table 7, observe that São Paulo ranks first, perhaps unsurprisingly, in terms of pollution emissions, both weighted and unweighted. More importantly, observe that the risk weighted rankings of the states are relatively similar across indices. HBEL and TRI offer slightly different rankings which may be explained by the fact that these are the long-term exposure indices in our analysis. The volume ranking, while providing a different ranking than the risk weighted rankings also performs relatively well, especially for those states ranked as the largest and those ranked as the smallest producers of toxic emissions. Hence, despite a few notable exceptions, state level rankings remain, for the most part, consistent across the risk indicators and with the volume indicator.

Table 7
Ranking of Brazilian states, indexed on TLV*

State	TLV	PEL	REL	MAK	HBEL	TEEL-0	TEEL-1	TEEL-2	TEEL-3	TRI	Volume
São Paulo	1	1	1	1	1	1	1	1	1	1	1
Paraná	2	2	5	2	2	4	2	2	2	5	4
Minas Gerais	3	4	2	4	6	2	4	4	3	4	2
Santa Catarina	4	3	6	3	3	6	3	3	4	6	3
Rio Grande do Sul	5	6	4	5	5	5	5	5	6	3	6
Pará	6	5	7	6	4	7	7	6	7	8	10
Rio de Janeiro	7	7	3	7	7	3	6	7	5	2	5
Ceará	8	10	9	8	14	8	8	8	8	10	7
Bahia	9	8	8	9	10	9	9	9	9	7	8
Mato Grosso do Sul	10	9	13	10	8	12	11	10	11	11	17
Pernambuco	11	12	10	11	15	10	10	11	10	9	9
Rondônia	12	13	16	13	9	15	14	13	15	18	22
Espírito Santo	13	11	11	12	12	11	13	12	12	13	12
Amazonas	14	14	14	15	11	14	16	14	16	15	18
Maranhão	15	15	17	17	13	17	17	15	17	14	21
Rio Grande do Norte	16	17	15	14	18	16	12	16	13	17	11
Goiás	17	16	12	16	17	13	15	17	14	12	13
Mato Grosso	18	18	19	19	16	19	19	18	19	20	20
Alagoas	19	19	18	18	21	18	18	19	18	19	16
Paraíba	20	20	20	20	24	20	20	20	20	22	14
Piauí	21	22	21	21	25	21	21	21	21	16	19
Distrito Federal	22	21	22	23	20	22	23	23	23	21	23
Sergipe	23	23	23	22	23	23	22	22	22	24	15
Acre	24	24	24	24	19	24	24	24	24	25	24
Tocantins	25	25	25	25	22	25	25	25	25	26	25
Amapá	26	26	26	26	26	26	26	26	26	23	26
Roraima	27	27	27	27	27	27	27	27	27	27	27

* - TLVs have been in use since 1946 and are the basis of numerous other indices (such as PEL, REL and MAK). In addition, TLVs are continuously revised to account for recent scientific research.

(iv) Pollution load in São Paulo & Rio de Janeiro

If we examine our estimates at a dis-aggregate (municipal) level for São Paulo and Rio, observe in Tables 8 and 9 that the rankings of municipals remain more or less identical across the risk-weighed indices, with the exceptions of HBEL and TRI for which the ranking of municipals vary the most with the other risk-weighted rankings. This is especially the case for São Paulo. Most striking however is the markedly different ranking obtained when risk is unweighted (volume ranking).

Table 8
Top 20 municipalities for Rio de Janeiro, indexed on TLV (1)

Municipal code	TLV	PEL	REL	MAK	HBEL	TEEL-0	TEEL-1	TEEL-2	TEEL-3	TRI	Volume
330455	1	1	1	1	1	1	1	1	1	1	1
330630	2	2	2	2	2	2	2	2	3	2	11
330170	3	3	3	3	3	5	3	3	2	3	2
330350	4	4	4	4	6	7	4	4	4	4	8
330340	5	6	5	7	11	9	8	6	7	8	4
330040	6	5	6	6	4	6	5	5	8	9	14
330330	7	10	8	5	5	3	6	8	9	6	6
330490	8	7	7	8	7	8	7	7	5	7	9
330010	9	31	14	9	8	4	11	20	24	15	17
330390	10	9	10	10	9	11	9	9	10	10	3
330025	11	12	11	11	16	14	10	10	6	5	16
330510	12	13	9	13	19	15	16	15	14	12	15
330030	13	11	13	12	10	10	14	11	15	13	22
330200	14	18	17	15	17	12	17	12	20	16	26
330580	15	15	15	17	15	20	19	16	19	20	10
330100	16	14	18	14	14	16	12	14	11	11	19
330240	17	19	20	19	20	17	21	18	22	19	30
330250	18	17	19	16	18	19	13	17	16	23	13
330080	19	21	31	22	12	29	24	23	29	27	39
330190	20	16	16	24	23	21	22	19	13	21	25

(1) - Total number of industrialized municipals is 75.

Table 9
Top 20 municipalities for São Paulo, indexed on TLV (1)

Municipal code	TLV	PEL	REL	MAK	HBEL	TEEL-0	TEEL-1	TEEL-2	TEEL-3	TRI	Volume
355030	1	1	1	1	1	1	1	1	1	1	1
354870	2	2	2	2	2	2	2	2	2	3	3
354840	3	4	3	4	40	9	7	4	8	11	23
351880	4	3	4	3	4	4	3	3	3	2	4
354780	5	5	5	5	10	5	5	5	4	4	14
351380	6	6	6	6	6	4	6	6	6	5	6
350950	7	7	9	7	12	7	4	7	7	8	5
351350	8	9	12	8	8	6	8	8	5	9	26
353800	9	13	7	18	31	15	26	15	25	31	66
354520	10	8	30	9	4	19	9	9	14	22	29
352590	11	11	16	10	7	13	10	10	11	14	10
355220	12	10	11	13	13	11	15	11	16	16	8
353070	13	17	14	11	18	24	11	16	17	45	19
352310	14	15	8	23	53	22	28	25	24	32	33
353870	15	12	13	15	11	12	16	13	19	19	21
350570	16	16	10	14	19	16	12	14	12	7	16
355250	17	14	38	12	5	27	13	12	15	27	11
354880	18	18	17	16	14	8	21	20	22	10	34
351300	19	23	15	29	41	31	31	28	29	28	50
353060	20	22	22	22	20	20	23	23	20	17	30

(1) - Total number of industrialized municipals is 548.

These results are confirmed upon calculating the Spearman rank correlation coefficient between each index. This coefficient, noted r_s, is calculated as follows:

$$r_s = 1 - \frac{6\sum_{i=1}^{n}(R_i - R_j)^2}{n(n^2-1)} \tag{4}$$

where R_i and R_j is the rank of the municipal under methodology i and j, and n is the number of pairs of ranks (n = 75 for Rio and 548 for São Paulo). Observe in Tables 10 and 11 that the rank correlation coefficients are significantly lower for the volume-based index, and higher across the risk-weighted indices with the exception of the long-term exposure HBEL and TRI indices.

Table 10
Rank correlation coefficients for Rio de Janeiro

	TLV	PEL	REL	MAK	HBEL	TEEL-0	TEEL-1	TEEL-2	TEEL-3	TRI	VOL
TLV	1.0000										
PEL	0.9586	1.0000									
REL	0.9695	0.9839	1.0000								
MAK	0.9916	0.9630	0.9706	1.0000							
HBEL	**0.9759**	**0.9687**	**0.9619**	**0.9691**	1.0000						
TEEL-0	0.9800	0.9630	0.9809	0.9870	**0.9617**	1.0000					
TEEL-1	0.9822	0.9619	0.9688	0.9940	**0.9557**	0.9878	1.0000				
TEEL-2	0.9864	0.9818	0.9830	0.9879	**0.9747**	0.9884	0.9871	1.0000			
TEEL-3	0.9744	0.9725	0.9757	0.9838	**0.9492**	0.9815	0.9880	0.9881	1.0000		
TRI	**0.9613**	**0.9451**	**0.9609**	**0.9648**	**0.9390**	**0.9627**	**0.9621**	**0.9565**	**0.9602**	1.0000	
VOL	**0.9368**	**0.8991**	**0.9209**	**0.9512**	**0.8944**	**0.9452**	**0.9514**	**0.9376**	**0.9570**	**0.9239**	1.0000

Table 11
Rank correlation coefficients for São Paulo

	TLV	PEL	REL	MAK	HBEL	TEEL-0	TEEL-1	TEEL-2	TEEL-3	TRI	VOL
TLV	1.0000										
PEL	0.9704	1.0000									
REL	0.9684	0.9818	1.0000								
MAK	0.9941	0.9751	0.9704	1.0000							
HBEL	**0.9560**	**0.9671**	**0.9351**	**0.9543**	1.0000						
TEEL-0	0.9791	0.9795	0.9812	0.9864	**0.9524**	1.0000					
TEEL-1	0.9849	0.9729	0.9687	0.9966	**0.9459**	0.9858	1.0000				
TEEL-2	0.9849	0.9904	0.9765	0.9921	**0.9654**	0.9873	0.9911	1.0000			
TEEL-3	0.9693	0.9775	0.9712	0.9834	**0.9352**	0.9802	0.9874	0.9897	1.0000		
TRI	**0.9596**	**0.9512**	**0.9585**	**0.9606**	**0.9427**	**0.9661**	**0.9570**	**0.9566**	**0.9510**	1.0000	
VOL	**0.9373**	**0.9172**	**0.9349**	**0.9529**	**0.8827**	**0.9518**	**0.9594**	**0.9429**	**0.9540**	**0.9300**	1.0000

Figures 2 and 3 compare the TLV and volume rankings of all municipals of Rio (Figure 2) and São Paulo (Figure 3). In these figures, a darker shading is to be interpreted as more pollution intensive.[8] Note in both figures that where the volume ranking would indicate a number of municipals as high priority (dark shade), the TLV index ranks a large number of these same municipal quite low, implying that the pollution loads are relatively non-toxic. These results indicate first that accounting for risk does make a significant difference in terms of identifying the areas (or industrial sectors) that should be deserving attention. They also indicate that in both São Paulo and Rio, a significant reduction of emissions of toxic chemicals could be obtained by allocating monitoring and control resources in a relatively small number or municipals.

Another noticeable result across the risk-weighted indices is between the short term (TEEL) and long term indices (HBEL and TRI). Note the lower correlation coefficients in Tables 10 and 11. In comparing the HBEL ranking with the short term lethal exposure index TEEL-3 in Figures 4 and 5, we observe a number of areas which have a larger potential to be lethal in the long term (i.e. Municipal code 330010; ranked 8th by HBEL, 24th by TEEL-3). Thus at greater levels of dis-aggregation, it appears that the outlook of risk (short or long term) becomes increasingly significant.

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[8] Graphs were constructed using ArcView 3.0 Geographical Information System. Estimates were divided into 7 shaded categories to highlight changes in relative ranking. For comparative purposes, the "volume" legend in Figures 2 and 3 were adjusted to match that of the TLV scale.

Figure 2: Volume vs. TLV risk-weighted ranking of municipals for the Rio de Janeiro region

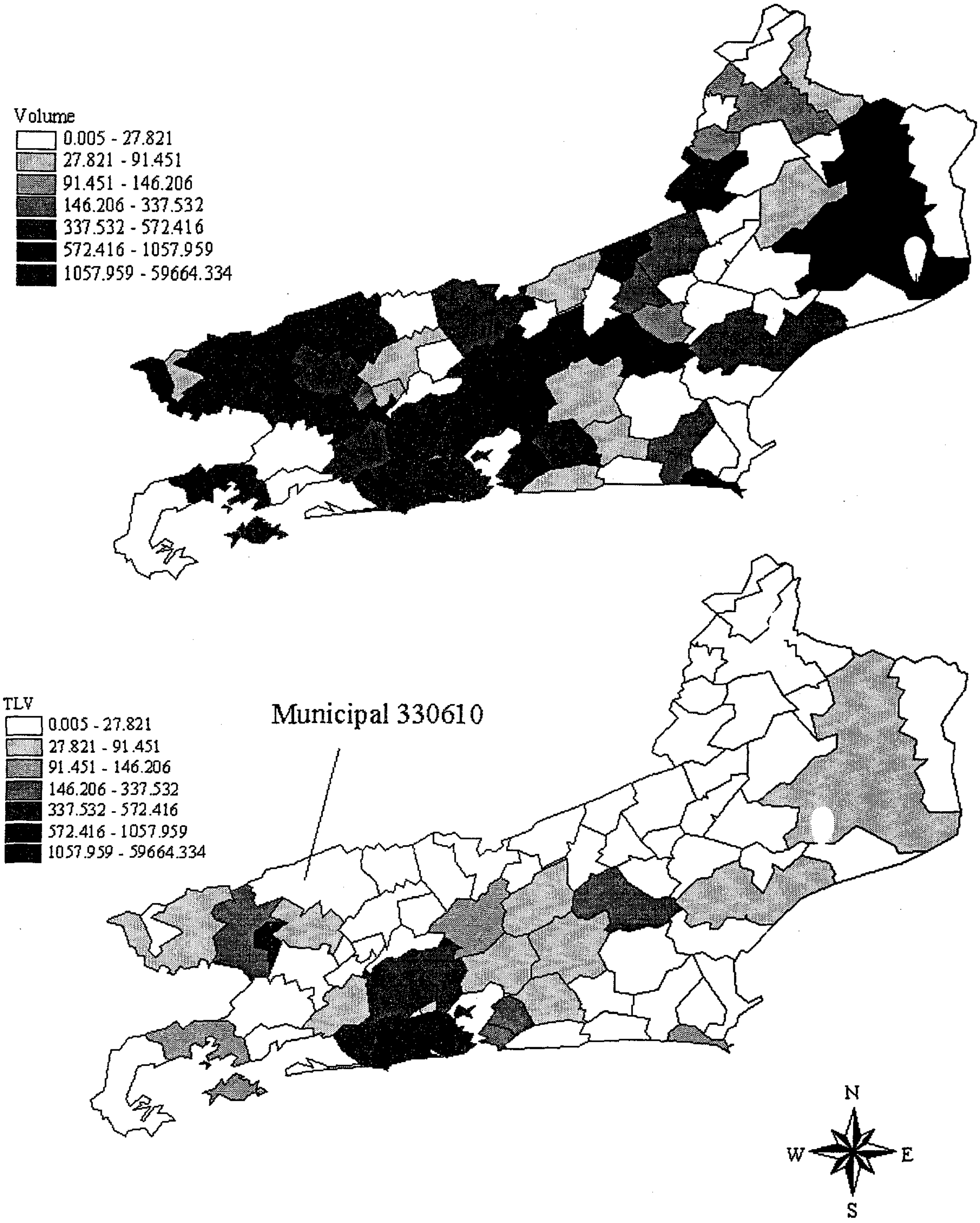


Figure 3: Volume vs. TLV risk-weighted ranking of municipals for the Sao Paulo region

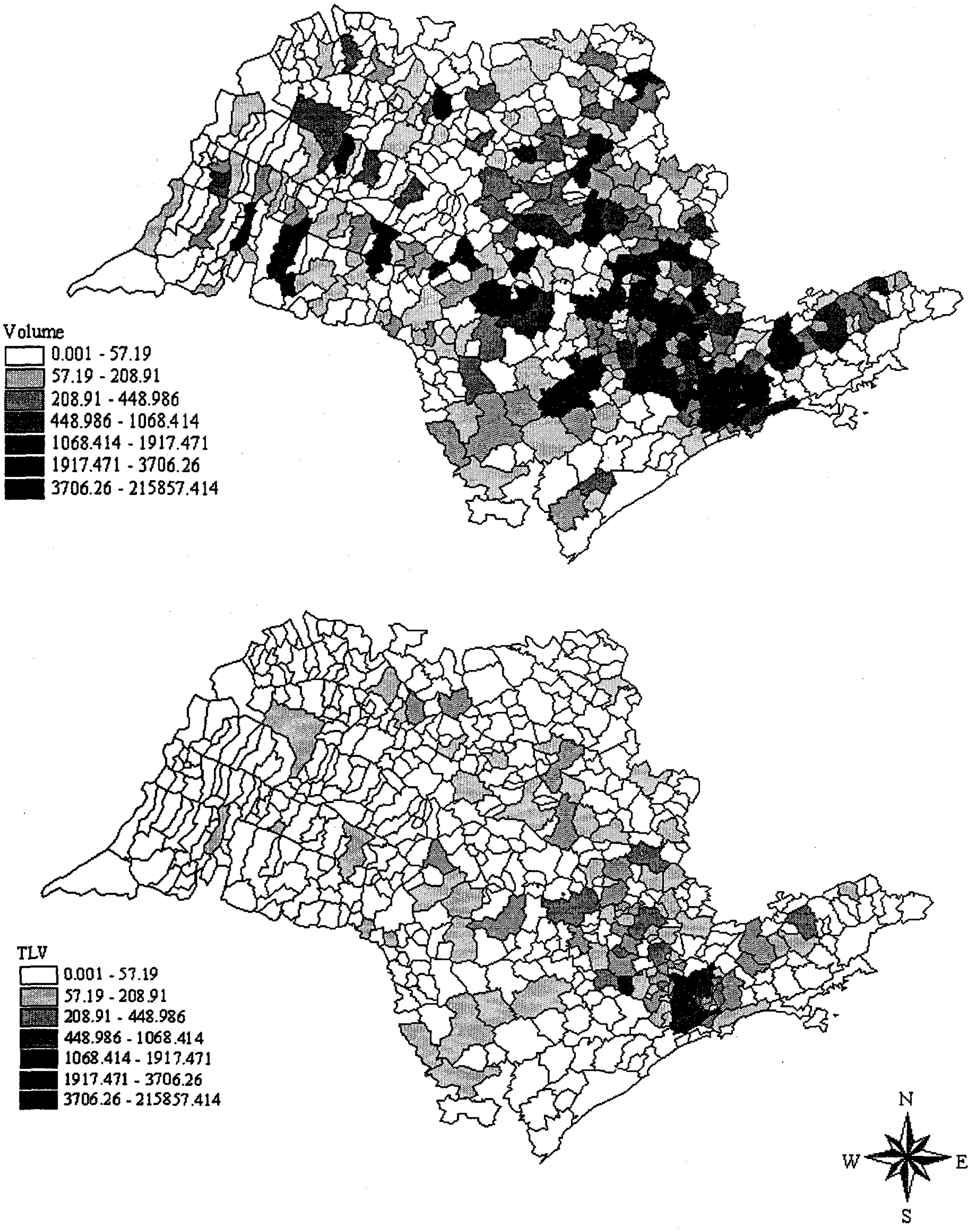


Figure 4: Acute (TEEL-3) vs. chronic-weighted (HBEL) ranking of municipals for the Rio de Janeiro region

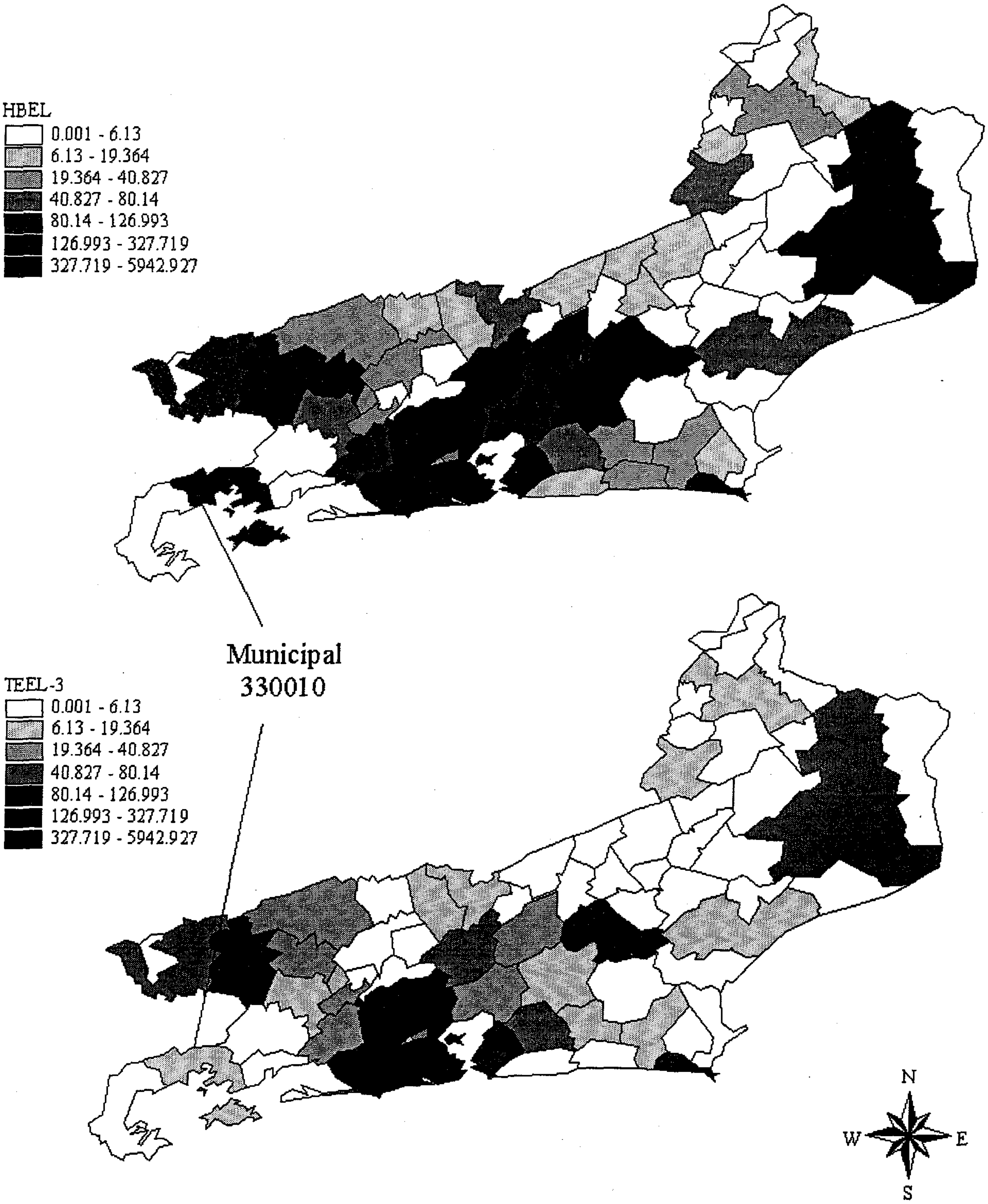
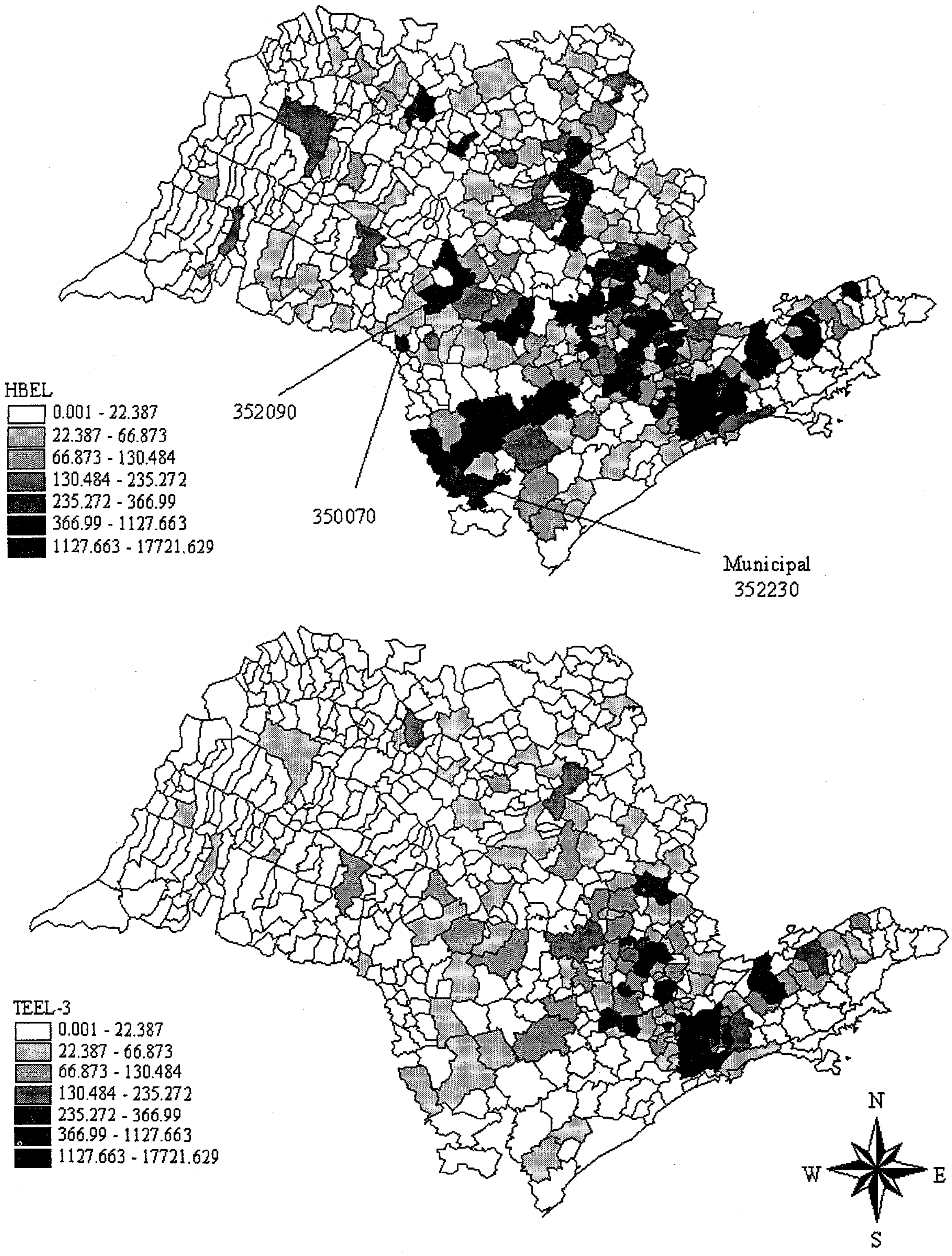


Figure 5: Acute (TEEL-3) vs. chronic-weighted (HBEL) ranking of municipals for the Sao Paulo region



IV. Conclusion

The accounting and public release of information pertaining to industrial toxic pollution emissions is meeting increasing criticism in that these listings typically do not account for the different toxicity risks associated with different pollutants: A firm emitting a large quantity of a relatively harmless substance would rank as a larger polluter than another firm emitting a small quantity of a very potent substance. It is argued that such "unweighted" rankings of firms may lead to a misallocation of resources and wrong prioritization of effort devoted to pollution control. This may be of particular importance for developing countries where resources devoted to pollution control are typically scarce.

In an attempt to account for the relative differences in chemical toxicity, a number of organizations have developed thresholds or exposure limits for various pollutants to account for their various toxicity risk. Given the large number of toxicity risk factors and methodologies currently available, a crucial issue pertains to the possibility that different risk indicators may yield different results, thus leading to different sets of priorities. In this paper, we have reviewed and applied to Brazil seven risk methodologies currently available, and constructed 10 different sets of toxicity risk factors from these indicators. Upon ranking states and municipals for their pollution intensity, results indicate that at the *state* level, risk weighted rankings remain largely the same across the 10 different sets of toxicity risk factors used in this paper. This result by and large also holds true at the *municipal* level with the exception of the long-term exposure indices (HBEL and TRI) which offer different rankings of pollution intensive municipals. Moreover, at the *state* level, the unweighted ranking is relatively similar to the risk weighted ranking. However, at the *municipal* level, significant differences were found between the risk weighted and unweighted rankings.

These findings suggest that it is of importance for environmental regulators to engage into weighting pollutants for their relative toxicity risk when prioritizing pollution control effort either at the industrial or regional level. This exercise appears to be of greater importance as one seeks to determine prioritization of pollution control effort at a greater level of dis-aggregation.

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Appendix A
Further details of risk indicators

TCLo - Toxic Concentration Low - the lowest concentration of a substance in air to which humans or animals have been exposed for any given period of time that has produced any toxic effect in humans or produced a carcinogenic, neoplastigenic, or teratogenic effect in animals or humans.

TDLo - Toxic Dose Low - the lowest dose of a substance introduced by any route, other than inhalation, over any given period of time and reported to produce any toxic effect in humans or to produce carcinogenic, neoplastigenic, or teratogenic effects in animals or humans.

LCLo - Lethal Concentration Low - the lowest concentration of a substance in air, other than LC50, which has been reported to have caused death in humans or animals. The reported concentrations may be entered for periods of exposure which are less than 24 hours (acute) or greater than 24 hours (subacute and chronic).

LDLo - Lethal Dose Low - the lowest dose (other than LD50) of a substance introduced by any route, other than inhalation, over any given period of time in one or more divided portions and reported to have caused death in humans or animals.

LD50 - Lethal Dose Fifty - a calculated dose of a substance which is expected to cause the death of 50% of an entire defined experimental animal population. It is determined from the exposure to the substance by any route other than inhalation of a significant number from that population.

Appendix B
Chemical substances in analysis

CAS	Substance
71556	1,1,1-TRICHLOROETHANE (METHYL CHLOROFORM)
79345	1,1,2,2-TETRACHLOROETHANE
76131	1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON 113)
79005	1,1,2-TRICHLOROETHANE
57147	1,1-DIMETHYL HYDRAZINE
120821	1,2,4-TRICHLOROBENZENE
95636	1,2,4-TRIMETHYLBENZENE (PSEUDOCUMENE)
106887	1,2-BUTYLENE OXIDE (1,2-EPOXYBUTANE)
96128	1,2-DIBROMO-3-CHLOROPROPANE (DBCP)
106934	1,2-DIBROMOETHANE (EDB) (ETHYLENE DIBROMIDE)
107062	1,2-DICHLOROETHANE (ETHYLENE DICHLORIDE)
540590	1,2-DICHLOROETHYLENE
78875	1,2-DICHLOROPROPANE (PROPYLENE DICHLORIDE)
122667	1,2-DIPHENYLHYDRAZINE (HYDRAZOBENZENE)
106990	1,3-BUTADIENE
541731	1,3-DICHLOROBENZENE (M-ISOMER)
542756	1,3-DICHLOROPROPYLENE
123911	1,4-DIOXANE (1,4-DIETHYLENE DIOXIDE)
82280	1-AMINO-2-METHYLANTHRAQUINONE
95954	2,4,5-TRICHLOROPHENOL
88062	2,4,6-TRICHLOROPHENOL
94757	2,4-D (DICHLOROPHENOXYACETIC ACID)
39156417	2,4-DIAMINO ANISOLE SULFATE
615054	2,4-DIAMINOSANISOLE
95807	2,4-DIAMINOTOLUENE
120832	2,4-DICHLOROPHENOL
105679	2,4-DIMETHYLPHENOL
51285	2,4-DINITROPHENOL
121142	2,4-DINITROTOLUENE
606202	2,6-DINITROTOLUENE
87627	2,6-XYLIDINE
53963	2-ACETOAMINOFLUORENE
117793	2-AMINOANTHRAQUINONE
532274	2-CHLOROACETOPHENONE (ALPHA) (PHENACYL CHORIDE)
110805	2-ETHOXYETHANOL (ETHYLENE GLYCOL MONOETHYL ETHER; CELLOSOLVE)
109864	2-METHOXYETHANOL (ETHYLENE GLYCOL MONOMETHYL ETHER; METHYL CELLOSOLVE)
88755	2-NITROPHENOL
79469	2-NITROPROPANE
90437	2-PHENYLPHENOL (SODIUM SALT)
91941	3,3'-DICHLOROBENZIDINE (AZO DYE)
119904	3,3'-DIMETHOXYBENZIDINE (AZO DYE; o-DIANISIDINE)
119937	3,3'-DIMETHYLBENZIDINE (AZO DYE; o-TOLIDINE)
101804	4,4'-DIAMINODIPHENYL ETHER (4,4'-OXYDIANILINE)
80057	4,4'-ISOPROPYLIDENEDIPHENOL (BISPHENOL A)
101144	4,4'-METHYLENE BIS(2-CHLOROANILINE) (MBOCA)
101611	4,4'-METHYLENE BIS(N,N-DIMETHYL) BENZELAMINE
101779	4,4'-METHYLENE DIANILINE (4,4'-DIAMINODIPHENYLMETHANE)
139651	4,4'-THIODIANILINE
534521	4,6-DINITRO-O-CRESOL
60093	4-AMINOAZOBENZENE

CAS	Substance
92671	4-AMINODIPHENYL (P-isomer)
60117	4-DIMETHYLAMINOAZOBENZENE
92933	4-NITRODIPHENYL (P-isomer)
100027	4-NITROPHENOL
99592	5-NITRO-O-ANISIDINE
75070	ACETALDEHYDE
60355	ACETAMIDE
67641	ACETONE
75058	ACETONITRILE
107028	ACROLEIN
79061	ACRYLAMIDE
79107	ACRYLIC ACID
107131	ACRYLONITRILE (VINYL CYANIDE)
309002	ALDRIN (1,4,5,8-DIMETHANONAPHTHALENE)
107051	ALLYL CHLORIDE
7429905	ALUMINUM (FUME OR DUST)
1344281	ALUMINUM OXIDE (FIBROUS FORM)
97563	AMINOAZOTOLUENE, O-ISOMER (C.I. SOLVENT YELLOW 3)
7664417	AMMONIA
6484522	AMMONIUM NITRATE (SOLUTION)
7783202	AMMONIUM SULFATE (SOLUTION)
62533	ANILINE
90040	ANISIDINE (O-ISOMER)
104949	ANISIDINE (P-ISOMER)
134292	ANISIDINE HYDROCHLORIDE (O-ISOMER)
120127	ANTHRACENE
7440360	ANTIMONY
7440382	ARSENIC
1332214	ASBESTOS (FRIABLE)
492808	AURAMINE (C.I. SOLVENT YELLOW 34)
7440393	BARIUM
98873	BENZAL CHLORIDE
55210	BENZAMIDE
71432	BENZENE
92875	BENZIDINE
98077	BENZOIC TRICHLORIDE (BENZYL TRICHLORIDE; TRICHLOROMETHYLBENZENE)
98884	BENZOYL CHLORIDE
94360	BENZOYL PEROXIDE
100447	BENZYL CHLORIDE
7440417	BERYLLIUM
92524	BIPHENYL (DIPHENYL)
108601	BIS(2-CHLORO-1-METHYLETHYL) ETHER (DICHLOROISOPROPYL ETHER)
111444	BIS(2-CHLOROETHYL) ETHER (DICHLOROETHYL ETHER; 2,2'-DICHLORODIETHYL ETHER)
103231	BIS(2-ETHYLHEXYL) ADIPATE
542881	BIS(CHLOROMETHYL) ETHER (DICHLOROMETHYL ETHER) (BCME)
75252	BROMOFORM (TRIBROMOMETHANE)
141322	BUTYL ACRYLATE (ACRYLIC ACID & N-BUYTL ESTER)
78922	BUTYL ALCOHOL (SEC-BUTANOL)
75650	BUTYL ALCOHOL (TERT-BUTANOL)
85687	BUTYL BENZYL PHTHALATE
123728	BUTYRALDEHYDE
2650182	C.I. ACID BLUE 9, DIAMMONIUM SALT
3844459	C.I. ACID BLUE 9, DISODIUM SALT
4680788	C.I. ACID GREEN 3

CAS	Substance
569642	C.I. BASIC GREEN 4
989388	C.I. BASIC RED 1
1937377	C.I. DIRECT BLACK 38
2602462	C.I. DIRECT BLUE 6
16071866	C.I. DIRECT BROWN 95
2832408	C.I. DISPERSE YELLOW 3
81889	C.I. FOOD RED 15
3761533	C.I. FOOD RED 5
3118976	C.I. SOLVENT ORANGE 7
842079	C.I. SOLVENT YELLOW 14
128665	C.I. VAT YELLOW 4
7440439	CADMIUM
156627	CALCIUM CYANAMIDE
133062	CAPTAN
63252	CARBARYL (SEVIN)
75150	CARBON DISULFIDE
56235	CARBON TETRACHLORIDE (TETRACHLOROMETHANE)
463581	CARBONYL SULFIDE
120809	CATECHOL (PYROCATECHOL)
133904	CHLORAMBEN (3-AMINO-2,5-DICHLOROBENZOIC ACID)
57749	CHLORDANE
7782505	CHLORINE
10049044	CHLORINE DIOXIDE
79118	CHLOROACETIC ACID
108907	CHLOROBENZENE (CHLORINATED BENZENE)
510156	CHLOROBENZILATE (4,4'-DICHLORO-BENZILIC ACID ETHYL ESTER)
67663	CHLOROFORM
107302	CHLOROMETHYL METHYL ETHER (CMME)
126998	CHLOROPRENE (BETA-CHLOROPRENE; NEOPRENE)
1897456	CHLOROTHALONIL
7440473	CHROMIUM
7440484	COBALT
7440508	COPPER (FUME OR DUST)
120718	CRESIDINE (P-ISOMER)
1319773	CRESOL (ALL ISOMERS)
108394	CRESOL (M-ISOMER)
95487	CRESOL (O-ISOMER)
106445	CRESOL (P-ISOMER)
98828	CUMENE
80159	CUMENE HYDROPEROXIDE
135206	CUPFERRON
110827	CYCLOHEXANE
1163195	DECABROMODIPHENYL OXIDE
117817	DI (2-ETHYLHEXYL) OR (SEC-OCTYL) PHTHALATE (DEHP)
2303164	DIALLATE
25376458	DIAMINOTOLUENE (MIXED ISOMERS)
334883	DIAZOMETHANE
132649	DIBENZOFURAN
84742	DIBUTYL PHTHALATE
25321226	DICHLOROBENZENE (MIXED ISOMERS)
95501	DICHLOROBENZENE 1,2-(O-ISOMER)
106467	DICHLOROBENZENE 1,4-(P-ISOMER)
75274	DICHLOROBROMOMETHANE (BROMOCHLORO.)
75092	DICHLOROMETHANE (METHYLENE CHLORIDE)

CAS	Substance
62737	DICHLORVOS
115322	DICOFOL
1464535	DIEPOXYBUTANE
111422	DIETHANOLAMINE
84662	DIETHYL PHTHALATE
64675	DIETHYL SULFATE
131113	DIMETHYL PHTHALATE
77781	DIMETHYL SULFATE
121697	DIMETHYLANILINE (N,N-DIMETHYLANILINE)
79447	DIMETHYLCARBAMOYL CHLORIDE
117840	DI-N-OCTYL PHTHALATE
106898	EPICHLOROHYDRIN (1-CHLORO-2,3-EPOXYPROPANE)
140885	ETHYL ACRYLATE (ACRYLIC ACID & ETHYL ESTER)
100414	ETHYL BENZENE
75003	ETHYL CHLORIDE (CHLOROETHANE)
541413	ETHYL CHLOROFORMATE
74851	ETHYLENE
107211	ETHYLENE GLYCOL
75218	ETHYLENE OXIDE
96457	ETHYLENE THIOUREA (2-IMIDAZOLIDINETHIONE)
151564	ETHYLENEIMINE
2164172	FLUOMETURON
50000	FORMALDEHYDE
76448	HEPTACHLOR
87683	HEXACHLORO-1,3-BUTADIENE
118741	HEXACHLOROBENZENE
77474	HEXACHLOROCYCLOPENTADIENE
67721	HEXACHLOROETHANE
1335871	HEXACHLORONAPHTHALENE
680319	HEXAMETHYL PHOSPHORAMIDE
302012	HYDRAZINE
10034932	HYDRAZINE SULFATE
7647010	HYDROCHLORIC ACID (HYDROGEN CHLORIDE)
74908	HYDROGEN CYANIDE
7664393	HYDROGEN FLUORIDE (HYDROFLUORIC ACID)
123319	HYDROQUINONE (DIHYDROXYBENZENE)
78842	ISOBUTYRALDEHYDE
67630	ISOPROPYL ALCOHOL (MANUFACTURING, STRONG-ACID PROCESS ONLY, NO PROCESS)
7439921	LEAD
58899	LINDANE (HEXACHLOROCYCLOHEXANE-gamma)
108316	MALEIC ANHYDRIDE
12427382	MANEB
7439965	MANGANESE
108781	MELAMINE
7439976	MERCURY
67561	METHANOL (METHYL ALCOHOL)
72435	METHOXYCHLOR
96333	METHYL ACRYLATE
74839	METHYL BROMIDE (BROMOMETHANE)
74873	METHYL CHLORIDE
78933	METHYL ETHYL KETONE (MEK; 2-BUTANONE)
60344	METHYL HYDRAZINE
74884	METHYL IODIDE
108101	METHYL ISOBUTYL KETONE (HEXONE)

CAS	Substance
624839	METHYL ISOCYANATE
80626	METHYL METHACRYLATE (METHACRYLIC ACID METHYL ESTER)
101688	METHYLENE BISPHENYL ISOCYANATE (DIPHENYLMETHANE-4,4'-DIISOCYANATE; MDI)
74953	METHYLENE BROMIDE
1634044	METHYL-TERT-BUTYL ETHER
90948	MICHLER'S KETONE
1313275	MOLYBDENUM TRIOXIDE
505602	MUSTARD GAS (2,2'-DICHLORODIETHYL SULFIDE)
91203	NAPHTHALENE
134327	NAPHTHYLAMINE (ALPHA or 2-NAPHTHYLAMINE)
91598	NAPHTHYLAMINE (BETA or 2-NAPHTHYLAMINE)
71363	N-BUTANOL (N-BUTYL ALCOHOL)
7440020	NICKEL
7697372	NITRIC ACID
139139	NITRILOTRIACETIC ACID
98953	NITROBENZENE
1836755	NITROFEN
51752	NITROGEN MUSTARD (N-METHYL-BIS(2-CHLOROETHYL)AMINE)
55630	NITROGLYCERIN (NG)
156105	NITROSODIPHENYLAMINE (P-ISOMER)
55185	N-NITROSODIETHYLAMINE (NDEA)
62759	N-NITROSODIMETHYLAMINE (N,N-DIMETHYLNITROSOAMINE)
924163	N-NITROSODI-N-BUTYLAMINE (DBN)
621647	N-NITROSODI-N-PROPYLAMINE (NDPA)
86306	N-NITROSODIPHENYLAMINE
4549400	N-NITROSOMETHYLVINYLAMINE
59892	N-NITROSOMORPHOLINE (NMOR)
759739	N-NITROSO-N-ETHYLUREA
684935	N-NITROSO-N-METHYLUREA
16543558	N-NITROSONORNICOTINE
100754	N-NITROSOPIPERIDINE (NPIP)
2234131	OCTACHLORONAPHTHALENE
20816120	OSMIUM TETROXIDE
56382	PARATHION
87865	PENTACHLOROPHENOL
79210	PERACETIC ACID
108952	PHENOL
106503	PHENYLENEDIAMINE (P-ISOMER)
75445	PHOSGENE (CARBONYL CHLORIDE)
7664382	PHOSPHORIC ACID
7723140	PHOSPHORUS (YELLOW OR WHITE)
85449	PHTHALIC ANHYDRIDE
88891	PICRIC ACID (2,4,6-TRINITROPHENOL)
1336363	POLYCHLORINATED BIPHENYLS (CHLORODIPHENYLS, 54% CHLORINE)
1120714	PROPANE SULTONE, 1,3-
57578	PROPIOLACTONE (BETA-PROPIOLACTONE)
123386	PROPIONALDEHYDE
114261	PROPOXUR (BAYGON)
115071	PROPYLENE
75569	PROPYLENE OXIDE (1,2-EPOXYPROPANE)
75558	PROPYLENEIMINE (2-METHYLAZIRIDINE)
110861	PYRIDINE
91225	QUINOLINE
106514	QUINONE (P-BENZOQUINONE)

CAS	Substance
82688	QUINTOZENE (PENTACHLORONITROBENZENE)
81072	SACCHARIN (MANUFACTURING ONLY, NO PROCESSOR REPORTING)
94597	SAFROLE
7782492	SELENIUM
7440224	SILVER
1310732	SODIUM HYDROXIDE (SOLUTION)
7757826	SODIUM SULFATE (SOLUTION)
100425	STYRENE (PHENYLETHYLENE; VINYL BENZENE)
96093	STYRENE OXIDE
7664939	SULFURIC ACID
100210	TEREPHTHALIC ACID
127184	TETRACHLOROETHYLENE (PERCHLOROETHYLENE)
961115	TETRACHLORVINPHOS (STIROFOS)
7440280	THALLIUM
62555	THIOACETAMIDE
62566	THIOUREA
1314201	THORIUM DIOXIDE
13463677	TITANIUM DIOXIDE
7550450	TITANIUM TETRACHLORIDE
108883	TOLUENE (TOLUOL)
584849	TOLUENE-2,4-DIISOCYANATE (TDI)
91087	TOLUENE-2,6-DIISOCYANATE
95534	TOLUIDINE (O-ISOMER)
636215	TOLUIDINE HYDROCHLORIDE (O-ISOMER)
8001352	TOXAPHENE (CHLORINATED CAMPHENE)
68768	TRIAZIQUONE
52686	TRICHLORFON
79016	TRICHLOROETHYLENE
1582098	TRIFLURALIN (2,6-DINITRO-N,N-DIPROPYL-4-(TRIFLUOROMETHYL) BENZENAMINE)
126727	TRIS(2,3-DIBROMOPROPYL) PHOSPHATE
51796	URETHANE (CARBAMIC ACID, ETHYL ESTER)
1314621	VANADIUM (PENTAOXIDE; FUME OR DUST)
108054	VINYL ACETATE
593602	VINYL BROMIDE (BROMOETHENE)
75014	VINYL CHLORIDE
75354	VINYLIDENE CHLORIDE (1,1-DICHLOROETHYLENE)
108383	XYLENE (M-ISOMER)
1330207	XYLENE (MIXED ISOMERS)
95476	XYLENE (O-ISOMER)
106423	XYLENE (P-ISOMER)
1314132	ZINC OXIDE (FUME OR DUST)
12122677	ZINEB

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