TABLE 2.1

PREVIOUSLY PUBLISHED PARTICLE FLUX ESTIMATES (10^9 kg/year)

SOURCE	WINDBLOWN DUST	VOLCANOES	SEA SALT	BIOMASS BURNING	METEORITES	VEGETATION	POLLEN & SPORES	TOTAL	COMMENTS
Global									
Hidy & Brock, 1970	7.3 to 730	3.7	730 to 1700	37 to 370 (extrapolated from US data)	0.02 to 0.2	1100			
Peterson & Junge, 1971	500 TPM (250 <5 Fm)	25 (<5 Fm)	1000 TPM (500 <5 Fm)	35 TPM (5 <5 Fm)	10 TPM				
Andren & Nriagu, 1979	500	25	1000			200			
Lantzy & Mackenzie, 1979	500	150 (+75 gas)							
Nriagu, 1978	500	25 (4 - 25)	1000	36 (3 - 370)	0.0036 (0.00005 - 10)	75 (75 - 1000)			
Matthews et al. 1971	100 to 500	25 to 150	300	3 to 10					particles <20 Fm
Matthews et al. 1971	60 to 300	15 to 90	180						particles <6 Fm
Prospero et al, 1983	70 60 to 360 128 ± 64 200 ± 100	4.2	1000 to 2000		1 to 10 0.02 to 0.2				
Pacyna, 1986	6 to 1100	6.5 to 150	300 to 2000	2 to 200					
Mosher & Duce, 1987	60 to 500	3.3 (sulphur particulate)	1000 to 10 000	5800 (includes human activity)					
Nriagu, 1989	60 to 500	15 to 50	1000 to 10 000	200 to 1500		continental volatile: 20 to 250; marine: 80 to 300	continental particulate: 100 to 500		
Canada									
Environment Canada, 1981a	15290		65370	0.66 0.073			9.5		particles <1.25 Fm particles >1.25 Fm
United States									
Evans & Cooper, 1980	229.655 (agricultural land)			1.427 - wildfire 0.512 - prescribed					1976 data; includes emissions by state

TPM - total particulate matter

TABLE 2.2

PREVIOUSLY PUBLISHED CADMIUM FLUX ESTIMATES
(10^6 kg/year)

SOURCE	WINDBLOWN DUST	VOLCANOES	SEA SALT	BIOMASS BURNING	METEORITES	VEGETATION	POLLEN & SPORES	TOTAL	COMMENTS
Global									
Lantzy & Mackenzie, 1979	0.25	0.04		1.5				1.79	fires includes wood burned for fuel
Nriagu, 1980a	0.1	0.52	0.001	0.012		0.21		0.843	
Jawarowski et al, 1981	0.85	0.65[a]	0.0017	0.65[a]	0.65[a]			1.5	a - total of volcanoes, fires, meteors
Jawarowski et al, 1981								590	based on glacier ice concentration and radionuclides
Galloway et al, 1982								0.29	soil dust + volcanic dust
Zoller, 1984	0.1 0.25	0.52 1.3	0.001 0.003	0.012 0.012		0.2		0.83 1.6	summarized from other sources
Pacyna, 1986	0.25 (0.05 - 0.85)	0.50 (0.04 - 7.8)	0.002 (0.001 - 0.4)	0.01 (0.01 - 1.5)		0.2 (0.05 - 2.7)		0.96	
Nriagu, 1989	0.01 - 0.4 median: 0.21	0.14 - 1.5 median: 0.82	0 - 0.11 median: 0.06	0 - 0.22 median: 0.11		continental volatile: 0.04 (0 - 0.8) marine:0.05 (0 - 0.10)	continental particulate: 0.15 (0 - 0.83)	1.44	

TABLE 2.3

PREVIOUSLY PUBLISHED COPPER FLUX ESTIMATES
(10^6 kg/year)

SOURCE	WINDBLOWN DUST	VOLCANOES	SEA SALT	BIOMASS BURNING	METEORITES	VEGETATION	POLLEN & SPORES	TOTAL	COMMENTS
Global									
Duce et al, 1976			3.3						
Lantzy & Mackenzie, 1979	10	9.3		35				54.3	fires includes wood burned for fuel
Nriagu, 1980b	12	3.6	0.08	0.3		2.5		18.5	'Copper in the Environment'
Galloway et al, 1982								19	soil dust + volcanic dust
Pacyna, 1986	12 (0.14 - 26)	4 (2.3 - 5.4)		0.3 (0.025 - 1.7)		2.5 (2.5-33)		18.9	'most acceptable' and range
Nriagu, 1989	8.0 (0.9 - 15)	9.4 (0.9 - 18)	3.6 (0.23 - 6.9)	3.8 (0.1 - 7.5)		continental volatile: 0.32 (0.01 - 0.62); marine: 0.39 (0.02 - 0.75)	Continental particulate: 2.6 (0.1 - 5.0)	27.7	median and range
Leygonie, 1993								28	

TABLE 2.4

PREVIOUSLY PUBLISHED LEAD FLUX ESTIMATES
(10^6 kg/year)

SOURCE	WINDBLOWN DUST	VOLCANOES	SEA SALT	BIOMASS BURNING	METEORITES	VEGETATION	POLLEN & SPORES	TOTAL	COMMENTS
Global									
Nriagu, 1978	16	0.4	0.00002	0.5	0.000007	1.65		18.55	
Lantzy & Mackenzie, 1979	5	0.87		6.8				12.7	fires includes wood burned for fuel
Jawarowski et al, 1981	0.6	23[a]	0.09	23[a]	23[a]			23.7	a - total of fires, volcanoes & cosmic dust
Jawarowski et al, 1981								4870	from glacier ice concentrations and radionuclides
Galloway et al, 1982								5.9	soil dust + volcanoes
Zoller, 1984	165	6.416	0.02 0.001	0.5 0.5		1.6		24.522	from other sources
Pacyna, 1986	10 (3 - 35)	6.4 (0.4 - 96)	0.1 (0.001 - 5)	0.5 (0.04 - 6.8)		1.6 (0.2 - 21)		18.6	
Nriagu, 1989	3.9 (0.3 - 7.5)	3.3 (0.54 - 6.0)	1.4 (0.02 - 2.8)	1.9 (0.06 - 3.8)		Cont. vol: 0.20 (0.01 - 0.38); Marine: 0.24 (0.02 - 0.45)	Continental part: 1.3 (0.02 - 2.5)	12 (0.97 - 23)	
Leygonie, 1993								12	

TABLE 2.5

PREVIOUSLY PUBLISHED MERCURY FLUX ESTIMATES (10^6 kg/year)

SOURCE	WINDBLOWN DUST	SOIL DEGASSING	VOLCANOES	SEA SALT	OCEAN DEGASSING	FRESHWATER DEGASSING	FIRES	METEORITE	VEGETATION	TOTAL	COMMENTS
Global											
Lantzy & Mackenzie, 1979	0.03		0.01				0.04			0.08	fires includes wood burned for fuel
Jawarowski et al, 1981	0.035		0.03[a] 0.007	0.006			0.03[a]	0.03[a]		0.071	a - total of fires, volcanoes, cosmic dust
Jawarowski et al, 1981										190	based on glacier ice concentrations & radionuclides
Galloway et al, 1982										0.04 particulate 25 volatile	
Zoller, 1984	0.005		>0.24	0.001			0.16			>0.4	from other sources
Fitzgerald, 1986		1 - 2[b]	0.06		2.3		1 - 2[b]		1 - 2[b]	3.3 - 4.3	b - total of continental sources
Pacyna, 1986	0.03 (0.005 - 0.035)		0.03 (0.01 - 0.24)	0.003 (0.001 - 0.006)			0.1 (0.04 - 0.16)			0.16	
Nriagu, 1989	0.05 (0 - 0.1)		1.0 (0.03 - 2.0)	0.02 (0 - 0.04)	0.77 (0.04 - 1.5) biogenic		0.02 (0 - 0.05)		volatile: 0.61 (0.02 - 1.2) particulate: 0.02 (0 - 0.04)	2.5 (0.1 - 4.9)	median & range
Slemr & Langer, 1992										1.5	based on total flux minus anthropogenic
Lindberg et al, 1998		1.4 - 3.2							0.85 - 2 (forests)		based on forest canopy & soil Hg flux values
Pongratz & Heumann, 1999										3	
Ebinghaus et al, 1999		0.58 - 1.26	0.02 - 0.09		2				0.85 - 2 (forests)		from other sources
Nriagu, 1999	0.0 (0 - 0.1)	1.12 (0.5 - 2.5)	0.447 (0.1 - 2.0)				0 (0 - 0.1)		0.9 (0.3 - 2.7)	2.467 (0.8 - 7.4)	based on earlier data; median & range
Canada											
Environment Canada, 1981b		1.4			0.011	0.0056	0		2.1		

TABLE 2.6

PREVIOUSLY PUBLISHED NICKEL FLUX ESTIMATES
(10^6 kg/year)

SOURCE	WINDBLOWN DUST	VOLCANOES	SEA SALT	BIOMASS BURNING	METEORITES	VEGETATION	POLLEN & SPORES	TOTAL	COMMENTS
Global									
Lantzy & Mackenzie, 1979	20	8.3		0.8					fires includes fuel wood
Schmidt & Andren, 1980	4.8	2.5	0.009	0.19	0.18	0.82		8.5	
Galloway et al, 1982								28	
Pacyna, 1986	20 (0.2 - 44)	3.8 (2.4 - 56)	0.04 (0.01 - 0.05)	0.6 (0.05 - 3.3)		1.6 (1.6 - 2.1)		26	
Nriagu, 1989	11 (1.8 - 20)	14 (0.93 - 28)	1.3 (0.1 - 2.6)	2.3 (0.1 - 4.5)		Continental: 0.10 (0 - 0.20) Marine: 0.12 (0.01 - 0.45)	0.51 (0.1 - 1.0)	30	
Leygonie, 1993								30	

TABLE 2.7

PREVIOUSLY PUBLISHED ZINC FLUX ESTIMATES
(10^6 kg/year)

SOURCE	WINDBLOWN DUST	VOLCANOES	SEA SALT	BIOMASS BURNING	METEORITES	VEGETATION	POLLEN & SPORES	TOTAL	COMMENTS
Global									
Lantzy & Mackenzie, 1979	25	10.8		250				285.8	
Nriagu & Davidson, 1980	25	7	0.21	2.1		9.4		43.7	
Zoller, 1984	2525	7.024	0.01 0.03	2.1 2.1		 9.4	3760.5	43.551	
Pacyna, 1986	25 (25 - 80)	10 (4.6 - 105)	0.02 (0.01 - 0.09)	0.5 (0.2 - 12)		10 (9.4 - 125)		4	
Nriagu, 1989	19 (3.0 - 35)	9.6 (0.31 - 19)	0.44 (0.02 - 0.86)	7.6 (0.3 - 15)		Continental: 2.5 (0.02 - 5.0) Marine: 3.0 (0.04 - 6.0)	2.6 (0.3 - 5.0)	45	
Leygonie, 1993								45	

TABLE 4.1

BIOME AREAS FOR CANADA

Biome/Ecoregion	Environment Canada (1981a) Estimate	Clayton *et al.* (1977) Estimate	Mean	% of Total Land Area in Each Biome
Tundra	2,675,944 km^2	3,883,500 km^2	3,279,722 km^2	34%
Coastal/Mountain Forest	532,470 km^2	517,800 km^2	525,135 km^2	5%
Boreal Forest	2,708,494 km^2	2,589,000 km^2	2,648,747 km^2	27%
Boreal Barrens	1,784,802	2,731,395 km^2	2,258,099 km^2	23%
Mixed Forest	399,466 km^2	481,555 km^2	440,511 km^2	5%
Grassland	598,428 km^2	613,593 km^2	606,011 km^2	6%
Total Land Area	8,699,604 km^2	10,816,843 km^2	9,758,224 km^2	100%
Freshwater	no data	no data	755,180 km^2 [a]	
Ocean territory	data not used	no data	6,500,000 km^2 [b]	

a - Statistics Canada 1998
b- Scott's Canadian Sourcebook 2000

TABLE 4.2

BIOME AREAS FOR CONTINENTAL NORTH AMERICA

Biome/Ecoregion	Canada (mean from Table 3.1)	United States	North America (total)	% of Total Land Area in Each Biome
Tundra	3,279,722 km^2	637,378 km^2 [b]	3,917,100 km^2	20.5 %
Coastal/Mountain Forest	525,135 km^2	784,194 km^2 [a]	1,309,329 km^2	6.8 %
Boreal Forest	2,648,747 km^2	0	2,648,747 km^2	13.8 %
Boreal Barrens	2,258,099 km^2	956,066 km^2 [b]	3,214,165 km^2	16.8 %
Mixed Forest	440,511 km^2	2,824,658 km^2 [a]	3,265,169 km^2	17.1%
Grassland	606,011 km^2	1,872,447 km^2 [a]	2,478,458 km^2	13.0 %
Shrubland	0	1,913,457 km^2 [a]	1,913,457 km^2	10.0 %
Desert	0	349,168 km^2 [a]	349,168 km^2	1.8 %
Rainforest	0	41,226 km^2 [b]	41,226 km^2	0.2 %
Total Land Area	9,758,224 km^2	9,378,594 km^2	19,136,818 km^2	100%
Freshwater	755,180 km^2	359,624 km^2 [c]	1,114,804 km^2	
Ocean territory	6,500,000 km^2	7,466,412 km^2 [d]	11,074,717 km^2	

a - based on Kuchler physiognomic types as presented in Leenhouts, 1998
b - U.S. (Eastern Energy and Land Use Team 1982)
c - U.S. Census Bureau 1999
d - World Almanac© and Book of Facts 2000 - smoothed outline of the coast multiplied by 200 nautical miles

TABLE 4.3
GLOBAL BIOME AREAS

Biome/Ecoregion	Bailey (1998) Estimate	% of Total Land Area in Each Biome
Tundra	19,967,000 km^2	14.0%
Boreal Forest	12,259,000 km^2	8.6%
Boreal Barrens	5,812,000 km^2	4.1%
Mixed Forest	7,910,000 km^2	5.5%
Grassland	26,850,000 km^2	18.7%
Coastal/Mountain Forest	7,285,000 km^2	5.1%
Shrubland	22,788,000 km^2	15.9%
Desert	26,567,000 km^2	18.5%
Rainforest	13,843,000 km^2	9.7%
Total Land Area	143,281,000 km^2	100%
Freshwater	2,000,000 km^2 [a]	
Ocean	361,000,000 km^2 [a]	

a - Pears 1985

TABLE 4.4
ECOREGION DUSTINESS RELATIVE TO SHRUBLAND

Ecoregion	Location	Source	Dusty Days/Year	Dusty Days Relative to Shrubland	Area (km)	Comments
Shrubland	South US	Hagen and Woodruff 1975	3*	1	1,913,500	
	Australia	Middleton 1984	1.2	0.4	2,000,000	
	Minimum			1		value of 1 was used because
	Most Probable			1		shrubland is already a triangular
	Maximum			1		distribution
Desert	various deserts	Middleton et al. 1986	34.4	11.47	7,500,000	
	U.S.	Brazel and Nickling 1987	2.1	0.7	349,200	
	Australia	Middleton 1984	2.7	0.9	3,000,000	
	Middle East	Middleton 1986b	6.6	2.2	2,390,634	
	Mongolia	Middleton 1991	15.5	5.2	1,570,000	
	SW Asia	Middleton 1986a	9**	3	3,099,450	
	Sudan	Middleton 1985	3.5	1.2	2,505,800	
	Mauritania	Middleton 1984	25.3	8.4	1030700	
	Minimum			0.7		weighted average was used
	Most Probable			5.75		for most likely value
	Maximum			11.47		
Grassland	North US	Hagen and Woodruff 1975	0.51*	0.17	1,872,500	
	Can. prairie	Wheaton and Chakravarti 1990	2.3	0.77	380,400	
	India	Middleton 1986a	0 - 5		3,000,000	
	Australia	Middleton 1984	0.23	0.077	2,000,000	
	North US	Orgill and Sehmel 1976		0.28	1,872,500	
	Minimum			0.077		weighted average was used
	Most Probable			0.21		for most likely value
	Maximum			0.77		
Coastal/ Mountain Forest	Australia	Middleton 1984	0.14	0.047	100,000	
	Rockies	Orgill and Sehmel 1976		0.023	530,000	
	Pacific coast	Orgill and Sehmel 1976		0.0005**	257,600	
	Minimum			0		weighted average was used
	Most Probable			0.01***		for most likely value
	Maximum			0.024***		
Mixed Forest	Australia	Middleton 1984	0.2	0.067	200,000	
	Great Lakes	Orgill and Sehmel 1976		0.066	850,500	
	NE US	Orgill and Sehmel 1976		0.00075**	332,500	
	SE US	Orgill and Sehmel 1976		0.1	1,171,700	
	Minimum			0		weighted average, median, and
	Most Probable			0.03***		arith. average were all similar and a middle value of 0.03 was chosen
	Maximum			0.05***		
Rainforest	India	Middleton 1986a	0	0	90,000	
	Australia	Middleton 1984	0.23	0.077	100,000	
	Minimum			0		
	Most Probable			0†		
	Maximum			0.039***		
Tundra			-	-		uniform distribution assumed
	Minimum			0		
	Maximum			0.005		
Boreal Forest			-	-		uniform distribution assumed
	Minimum			0		
	Maximum			0.01		
Boreal Barrens			-	-		uniform distribution assumed
	Minimum			0		
	Maximum			0.01		

* - Hagen and Woodruff 1975 describe their dusty days in terms of 11.3 km visibility. Brazel and Nickling 1987 determined the conversion factor between dust storm frequency at 11.3 km and 1 km visibility to be 0.16.

This is supported by Middleton 1986b who determined the conversion factor to be 0.15.

** - Estimated from contour maps

*** - Values for coastal/mountain forest and mixed/Great Lakes forest were divided by 2 because much of the dust originates from other sources

† - The most likely value is thought to be 0 because Middleton presents one high value that skews his results

TABLE 4.5
CADMIUM CONCENTRATIONS IN SOILS
(mg/kg)

Location	Soil Type	Mean	Standard Deviation	Minimum	Maximum	Median	Reference
CANADA							
Nova Scotia	agricultural surface soil			0.11	0.43		Environment Canada, 1996a
Ontario		1.14		0.55	1.72		Environment Canada, 1996a
Ontario, SW	A-C horizons			ND	1.7		Environment Canada, 1996a
Ontario	agricultural surface soil	0.56	0.69	0.1	8.1		Frank et al., 1976
Ontario	agricultural surface soil	0.95		0.19	4.3		Environment Canada, 1996a
Ontario	agricultural surface soil	<0.5		<0.5	2.4		Environment Canada, 1996a
Ontario	agricultural soils	0.8					Environment Canada, 1996a
Ontario	topsoil	0.97		0.1	8.1		Environment Canada, 1996a
Manitoba, SW	A horizon	1.1	0.32	0.5	1.7		Environment Canada, 1996a
Manitoba, SW	A horizon	0.95	0.32	0.4	1.7		Environment Canada, 1996a
Alberta, SE, central	A-C horizons			0.06	0.53		Environment Canada, 1996a
Alberta, NW	agricultural surface soil	0.3					Environment Canada, 1996a
Prairie	plowed agricultural soil	0.3		<0.2	3.8		Environment Canada, 1996a
BC, Fraser River	agricultural soil	0.88		<0.5	4.67		Environment Canada, 1996a
BC, North	surface soil, river bank	0.38	0.45	0.1	1.8		Environment Canada, 1996a
BC , Laird River	surface soil, river bank	0.26	0.15	0.1	0.5		Environment Canada, 1996a
BC	topsoil	0.88		<0.1	4.67		Environment Canada, 1996a
Canada	topsoil	0.9		0.4	1.7		Environment Canada, 1996a
Canada		0.07		0.01	0.1		Environment Canada, 1996a
mean		*0.68*		*0.23*	*2.82*		
minimum		*0.07*		*0.01*	*0.10*		
maximum		*1.14*		*0.55*	*8.10*		
UNITED STATES							
Michigan	topsoil	0.56					Ure and Berrow, 1982
New England	surface soil	0.32					Frink, 1996
United States		0.56	0.12	1.82			Ure and Berrow, 1982
United States	agricultural surface soil	0.265	0.253	<0.01	2	0.2	Frink, 1996
United States	surficial materials	<1.0					Frink, 1996
mean		*0.54*		*0.92*	*2*		
minimum		*0.27*		*0.01*	*2*		
maximum		*0.56*		*1.82*	*2*		

TABLE 4.5 (continued)
CADMIUM CONCENTRATIONS IN SOILS
(mg/kg)

Location	Soil Type	Mean	Standard Deviation	Minimum	Maximum	Median	Reference
EUROPE							
England	soil	0.7					Frink, 1996
England	topsoil	0.3		<1	4		Ure and Berrow, 1982
England and Wales	contam./uncontam. sites	1.2	2.4			0.9	McGrath, 1986
England and Wales	topsoil	0.8		<0.2	40.9	0.7	Reimann and Caritat, 1998
England and Wales	topsoil			0.08	10	1	Ure and Berrow, 1982
England and Wales	topsoil	0.63		0.27	1.04		Ure and Berrow, 1982
Wales	topsoil	1.78		0.4	2.3		Ure and Berrow, 1982
Wales	profiles	0.6		0.4	0.9		Ure and Berrow, 1982
Wales	topsoil	1.1					Ure and Berrow, 1982
Scotland	topsoil	0.77		<0.3	1.5		Ure and Berrow, 1982
Scotland	profiles	0.83		<0.005	1.4		Ure and Berrow, 1982
Scotland	topsoil	0.66		<0.25	1.4		Ure and Berrow, 1982
Scotland	soil	0.47					Frink, 1996
UK	soil			0.08	10	1	Alloway, 1995
Netherlands	soil	1.76					Frink, 1996
Sweden	soil	1.2					Frink, 1996
Sweden	topsoil	0.22		0.03	2.3		Ure and Berrow, 1982
Norway	topsoil	0.57		0.02	3.7		Ure and Berrow, 1982
Norway	soil	0.95					Frink, 1996
Finland	agricultural surface soil			<0.01	0.448	0.117	Reimann and Caritat, 1998
Denmark	topsoil	0.26					Ure and Berrow, 1982
Austria	soil	0.2					Frink, 1996
Belgium	soil	0.33					Frink, 1996
Denmark	soil	0.24					Frink, 1996
France	soil	0.74					Frink, 1996
Germany	soil	0.52					Frink, 1996
Italy	soil	0.53					Frink, 1996
Spain	soil	1.7					Frink, 1996
Europe, central eastern	soil	0.51					Frink, 1996
mean		*0.75*		*0.23*	*6.15*		
minimum		*0.20*		*0.005*	*0.448*		
maximum		*1.78*		*1.00*	*40.90*		
ASIA							
Japan	rice paddies	0.4					Alloway, 1995

TABLE 4.5 (continued)
CADMIUM CONCENTRATIONS IN SOILS
(mg/kg)

Location	Soil Type	Mean	Standard Deviation	Minimum	Maximum	Median	Reference
SOUTH PACIFIC							
Australia	topsoil	0.092		0.032	0.212		Ure and Berrow, 1982
Australia	topsoil	0.28		0.013	0.56		Ure and Berrow, 1982
mean		*0.19*		*0.023*	*0.39*		
minimum		*0.092*		*0.013*	*0.212*		
maximum		*0.28*		*0.032*	*0.56*		
GLOBAL AVERAGES							
world		0.3					Reimann and Caritat, 1998
world	soil/surficial materials			0.02	2	0.35	Frink, 1996
world	soil/surficial materials			0.01	3		Pais and Jones, 1997
world	soil/surficial materials	0.5					Frink, 1996
world	soil	0.06					Frink, 1996
world	soil	0.06					Frink, 1996
world	soil	0.5					Frink, 1996
world	soil	0.06					Frink, 1996
world	soil 0-100 cm	0.2					Nriagu, 1980a
world	survey	0.53		0.06	1.1		Alloway, 1995
mean		*0.28*		*0.03*	*2*		
minimum		*0.06*		*0.01*	*1.1*		
maximum		*0.53*		*0.06*	*3*		
Summary							
Canada		0.68		0.07	1.14		
North America		0.61		0.07	1.14		
Global		0.47		0.07	1.78		

TABLE 4.6
COPPER CONCENTRATIONS IN SOILS
(mg/kg)

Location	Soil Type	Mean	Standard Deviation	Minimum	Maximum	Median	Reference
CANADA							
Nova Scotia	topsoil	19.5		3	81		Ure and Berrow, 1982
Nova Scotia	surface soil			17	22		McKeague et al., 1979
New Brunswick	normal soil			7	22		McKeague et al., 1979
New Brunswick		14.5		<5	230		Ure and Berrow, 1982
New Brunswick	horizons			16	472		McKeague et al., 1979
Appalachian	A horizon only	11					McKeague et al., 1979
Ontario	background	25					CCME, 1997
Ontario	surface soil			8	31		McKeague et al., 1979
Ontario	agricultural soils	25.4	21.5	2.1	144		Frank et al., 1976
Ontario	A horizon	22					CCME, 1997
Ontario	control soil in study	25		10	53		CCME, 1997
Ontario		22.1		14	32.2		CCME, 1997
Ontario	surface soil			4	24		McKeague et al., 1979
Ontario	control soil in study	40		<9	76		CCME, 1997
Ontario, SW	agricultural watersheds	18.9					CCME, 1997
St. Lawrence Lowland	A horizon only	16					McKeague et al., 1979
Eastern Canada	organic soils	145.3		8.3	537.5		CCME, 1997
Canada Shield	A horizon only	10		6	16		McKeague et al., 1979
Manitoba	agricultural mineral soils	24.4		8	61		Ure and Berrow, 1982
Manitoba	peatlands	6.5		2	11.8		CCME, 1997
Manitoba	A and C horizons			2	43		McKeague et al., 1979
Alberta	Br. Chernozem	24					CCME, 1997
Alberta	Dk. Br. Chernozem	19					CCME, 1997
Alberta	Bl. Chernozem	29					CCME, 1997
Alberta	grey Luvisol	49					CCME, 1997
Alberta	dark-grey soils and gleysols	29.5		15.4	38.8		CCME, 1997
Alberta	Luvisolic, Solonetzic, Podzolic	15.7		2	32.8		CCME, 1997
Alberta	glacial till			5	40		McKeague et al., 1979
Interior plains	A horizon only	18					McKeague et al., 1979
Interior plains	horizons			7	24		McKeague et al., 1979
BC	horizons			3	91		McKeague et al., 1979
Cordilleran	A horizon only	42		28	54		McKeague et al., 1979
Canada		11.2		1	23		Ure and Berrow, 1982
Canada	plowed agricultural topsoil			5	221	19	Reimann and Caritat, 1998
mean		*27.6*		*7.8*	*99.2*		
min		*6.5*		*1*	*11.8*		
max		*145.3*		*28*	*537.5*		

TABLE 4.6 (continued)
COPPER CONCENTRATIONS IN SOILS
(mg/kg)

Location	Soil Type	Mean	Standard Deviation	Minimum	Maximum	Median	Reference
UNITED STATES							
New England	surface soil	40.7					Frink, 1996
United States, SE	topsoil	26.2		5	74		Ure and Berrow, 1982
Louisiana		20.3		3	49		Ure and Berrow, 1982
Missouri	agricultural surface soil	19					Thornton, 1979
Colorado		16.2		2	92		Ure and Berrow, 1982
California		31.5		0	112		Ure and Berrow, 1982
United States	agricultural surface soil	29.6	40.6	0.6	495	18.5	Frink, 1996 (arithmetic)
United States	surficial materials	14	2.54				Frink, 1996 (geometric)
United States	surficial materials	13	2.8	<1	700		Frink, 1996 (geometric)
United States		28		4	98		Ure and Berrow, 1982
United States		60.6		5	203		Ure and Berrow, 1982
United States	topsoil	25		<1	25		Ure and Berrow, 1982
mean		*27*		*2.4*	*205*		
min		*13*		*0*	*25*		
max		*60.6*		*5*	*700*		

TABLE 4.6 (continued)
COPPER CONCENTRATIONS IN SOILS
(mg/kg)

Location	Soil Type	Mean	Standard Deviation	Minimum	Maximum	Median	Reference
EUROPE							
England	soil	15.6					Frink, 1996
England	topsoil			3	80	14	Ure and Berrow, 1982
England	topsoil	48.6		16	150		Ure and Berrow, 1982
England and Wales	contam./uncontam. sites	23	27			18	McGrath, 1986
England and Wales	topsoil			1.8	195	17	Ure and Berrow, 1982
England and Wales	soil	20					Thornton, 1979
Wales	topsoil	34		14	73		Ure and Berrow, 1982
Wales	topsoil	11					Ure and Berrow, 1982
Wales	profiles	44.4		3	150		Ure and Berrow, 1982
Scotland	profiles	11.5		<5	40		Ure and Berrow, 1982
Scotland	profiles	23		3	50		Ure and Berrow, 1982
Scotland	soil	23					Frink, 1996
Britain		18.8		1	65		Ure and Berrow, 1982
Britain	topsoil	20.1		4.4	64		Ure and Berrow, 1982
Finland	topsoil	85.7		<30	300		Ure and Berrow, 1982
Finland				<1	54.8	14.7	Reimann and Caritat, 1998
Sweden	topsoil	14.6		1.5	190		Ure and Berrow, 1982
Sweden	soil	8.5					Frink, 1996
Norway	soil	19					Frink, 1996
Denmark	soil	11.1					Frink, 1996
Denmark	topsoil	12.5					Ure and Berrow, 1982
Netherlands	soil	18.6					Frink, 1996
Spain	soil	14					Frink, 1996
Spain	topsoil	20		6	139		Ure and Berrow, 1982
Spain	profiles	21.9		1.4	191		Ure and Berrow, 1982
Portugal	soil	24.5					Frink, 1996
Italy	soil	51					Frink, 1996
France	soil	13					Frink, 1996
Austria	soil	17					Frink, 1996
Belgium	soil	17					Frink, 1996
Germany	soil	22					Frink, 1996
Germany, beech forest	organic layer	80					Heinrichs and Mayer, 1980
Germany, beech forest	mineral soils	24					Heinrichs and Mayer, 1980
Germany, spruce forest	organic layer	59					Heinrichs and Mayer, 1980
Germany, spruce forest	mineral soils	27					Heinrichs and Mayer, 1980
Poland	profiles	21		11.5	36		Ure and Berrow, 1982
Poland	profiles	8.8		1.6	29		Ure and Berrow, 1982
Poland	profiles	21.7		4.8	89		Ure and Berrow, 1982
Poland	profiles	7.5		2.8	27		Ure and Berrow, 1982
Europe, central eastern	soil	17.5					Frink, 1996
USSR, European	topsoil	21.5					Ure and Berrow, 1982
USSR, European	topsoil	22.9		1.8	70		Ure and Berrow, 1982
USSR	topsoil	15.2					Ure and Berrow, 1982
mean		*24.7*		*6.0*	*104.9*		
min		*7.5*		*1*	*27*		
max		*85.7*		*30*	*300*		

TABLE 4.6 (continued)
COPPER CONCENTRATIONS IN SOILS
(mg/kg)

Location	Soil Type	Mean	Standard Deviation	Minimum	Maximum	Median	Reference
AFRICA							
Israel	profiles	31.3		14	61.5		Ure and Berrow, 1982
Israel	profiles	15.4		2.7	34		Ure and Berrow, 1982
Israel	profiles	22.9		1.9	57		Ure and Berrow, 1982
Egypt	topsoil	29.5		3.5	72		Ure and Berrow, 1982
Ghana	profiles	26.7		10	100		Ure and Berrow, 1982
Cameroon	profiles	31.3		11.5	68		Ure and Berrow, 1982
Madagascar	profiles	36.7		5	91		Ure and Berrow, 1982
South Africa	topsoil	14.7		2.1	30		Ure and Berrow, 1982
mean		*26.1*		*6.3*	*64.2*		
min		*14.7*		*1.9*	*30*		
max		*36.7*		*14*	*100*		
ASIA							
India	topsoil	53.4		13	100		Ure and Berrow, 1982
India	topsoil	31.8		14	84		Ure and Berrow, 1982
India	topsoil	43		31	50		Ure and Berrow, 1982
India	topsoil	68.4		20	229		Ure and Berrow, 1982
India	soil			11	175		Thornton, 1979
India	soil			8	46		Thornton, 1979
Burma	topsoil	16.6					Ure and Berrow, 1982
Burma	profiles	19.1		4	48		Ure and Berrow, 1982
China	profiles	22		4	72		Ure and Berrow, 1982
Japan	profiles	42.9		12	107		Ure and Berrow, 1982
Japan	profiles	45		2	160		Ure and Berrow, 1982
mean		*38.0*		*12*	*107*		
min		*16.6*		*2*	*46*		
max		*68.4*		*31*	*229*		
SOUTH PACIFIC							
Papua-New Guinea	profiles	79.1		27	135		Ure and Berrow, 1982
Australia	topsoil	43.4		1	190		Ure and Berrow, 1982
Australia	profiles	19.2		3.5	150		Ure and Berrow, 1982
Australia	topsoil	9.9		2	50		Ure and Berrow, 1982
S.W. Pacific	topsoil	49.1					Ure and Berrow, 1982
mean		*40.14*		*8*	*131*		
min		*9.9*		*1*	*50*		
max		*79.1*		*27*	*190*		
SOUTH AMERICA							
Galapagos	profiles	50		7	130		Ure and Berrow, 1982
Brazil	profiles	54.5		1	389		Ure and Berrow, 1982
mean		*52.3*		*4*	*260*		
min		*50*		*1*	*130*		
max		*54.5*		*7*	*389*		

TABLE 4.6 (continued)
COPPER CONCENTRATIONS IN SOILS
(mg/kg)

Location	Soil Type	Mean	Standard Deviation	Minimum	Maximum	Median	Reference
GLOBAL AVERAGES							
world						25	Reimann and Caritat, 1998
world	soil/surficial materials	20					Frink, 1996
world	soil/surficial materials			2	250	30	Frink, 1996
world	soil/surficial materials	20					Frink, 1996
world	soil/surficial materials					15	Frink, 1996
world	soil/surficial materials	25					Pais and Jones, 1997
world	soil/surficial materials	18		2	100		Pais and Jones, 1997 (geometric)
world	soil/surficial materials	20					Frink, 1996
world	soil	20					Frink, 1996
world	soil	20					Frink, 1996
world	soil	30					Frink, 1996
mean		*22*		*2*	*175*	*23*	
min		*18*		*2*	*100*	*15*	
max		*30*		*2*	*250*	*30*	
Summary							
Canada		27.6		6.5	145.3		
North America		27.3		6.5	145.3		
Global		34.7		6.5	145.3		

TABLE 4.7
LEAD CONCENTRATIONS IN SOILS
(mg/kg)

Location	Soil Type	Mean	Standard Deviation	Minimum	Maximum	Median	Reference
CANADA							
Appalachian	A horizon only	12					McKeague et al., 1979
New Brunswick	normal soil			15	75		McKeague et al., 1979
New Brunswick		26.5		<5	420		Ure and Berrow, 1982
Ontario		23		8.2	45		Ure and Berrow, 1982
Ontario	uncontaminated agricultural	14.1	11	1.5	50.1		Frank et al., 1976
St. Lawrence Lowland	A horizon only	23					McKeague et al., 1979
Canada, East		21		3	108		Ure and Berrow, 1982
Canada Shield	A horizon only	21		16	28		McKeague et al., 1979
Saskatchewan	A horizon only			6	9		McKeague et al., 1979
Interior plains	A horizon only	15					McKeague et al., 1979
Interior plains	horizons			6	17		McKeague et al., 1979
BC	topsoil	10.4					Ure and Berrow, 1982
BC	surface soil			41	61		McKeague et al., 1979
Cordilleran	A horizon only	19		14	26		McKeague et al., 1979
Canada	topsoil	20.7		7	43		Ure and Berrow, 1982
Canada		12					Nriagu, 1978
Canada	plowed agricultural soils			3	192	14	Reimann and Caritat, 1998
mean		*18*		*10*	*90*		
min		*10.4*		*1.5*	*9*		
max		*26.5*		*41*	*420*		
UNITED STATES							
New England	surface soil	24.8					Frink, 1996
United States, SE	topsoil	29.2		7	57		Ure and Berrow, 1982
Alaska	uncontaminated soils	14					Nriagu, 1978
United States	topsoil	20		<10	700		Ure and Berrow, 1982
United States		13.4		<10	24		Ure and Berrow, 1982
United States	agricultural surface soil	12.3	7.5	<1	135	11	Frink, 1996 (arithmetic)
United States	topsoil	44.1		14	96		Ure and Berrow, 1982
United States	surfical materials	14	1.96				Frink, 1996 (geometric)
United States	surfical materials	14	1.95	<10	300		Frink, 1996 (geometric)
United States	uncontaminated soils	18					Nriagu, 1978
United States	background levels	20					Environment Canada, 1996b
United States		75.8		6	155		Ure and Berrow, 1982
mean		*25*		*8*	*210*		
min		*12.3*		*1*	*24*		
max		*75.8*		*14*	*700*		

TABLE 4.7 (continued)
LEAD CONCENTRATIONS IN SOILS
(mg/kg)

Location	Soil Type	Mean	Standard Deviation	Minimum	Maximum	Median	Reference
EUROPE							
England	uncontaminated soils	14					Nriagu, 1978
England	topsoil	114		48	307		Ure and Berrow, 1982
England	profiles	47.8		15	160		Ure and Berrow, 1982
England	soil	48.7					Frink, 1996
England and Wales	topsoil	42		15	106		Davies, 1995 (geometric)
England and Wales	contam./uncontam. sites	75	338			42	McGrath, 1986
England and Wales	topsoil			5	1200	42	Ure and Berrow, 1982
Wales	profiles	96.9		2	200		Ure and Berrow, 1982
Wales	topsoil	39		<1	356		Ure and Berrow, 1982
Wales	uncontaminated soils	42					Nriagu, 1978
Scotland	profiles	24.1		10	80		Ure and Berrow, 1982
Scotland	profiles	30		<3	400		Ure and Berrow, 1982
Scotland	profiles	6.7		6	20		Ure and Berrow, 1982
Scotland	soil	19					Frink, 1996
Scotland	mineral soils	13					Davies, 1995 (geometric)
Scotland	organic soils	30					Davies, 1995 (geometric)
Sweden	topsoil	15.9		2.2	364		Ure and Berrow, 1982
Sweden	uncontaminated soils	12					Nriagu, 1978
Sweden	soil	69					Frink, 1996
Denmark	topsoil	24.1					Ure and Berrow, 1982
Denmark	soil	16					Frink, 1996
Norway	soil	61					Frink, 1996
Finland	topsoil	135		<10	600		Ure and Berrow, 1982
Finland				<5	43.2	7.45	Reimann and Caritat, 1998
Netherlands	soil	60.2					Frink, 1996
Spain	uncontaminated soils	10					Nriagu, 1978
Spain	soil	35					Frink, 1996
France	soil	30					Frink, 1996
Italy	soil	21					Frink, 1996
Italy	uncontaminated soils	13					Nriagu, 1978
Germany	soil	56					Frink, 1996
Germany		7.9		<4	11		Davies, 1995 (geometric)
Germany, beech forest	mineral soils	61					Heinrichs and Mayer, 1980
Germany, spruce forest	mineral soils	81					Heinrichs and Mayer, 1980
Austria	soil	15					Frink, 1996
Austria	uncontaminated soils	16					Nriagu, 1978
Belgium	uncontaminated soils	21					Nriagu, 1978
Belgium	soil	38					Frink, 1996
Poland	profiles	20.8		3.3	102		Ure and Berrow, 1982
Silesia	uncontaminated soils	28					Nriagu, 1978
Europe, central eastern	soil	32.1					Frink, 1996
Russia	uncontaminated soils	12					Nriagu, 1978
mean		*38*		*9*	*282*		
min		*6.7*		*1*	*11*		
max		*135*		*48*	*1200*		

TABLE 4.7 (continued)
LEAD CONCENTRATIONS IN SOILS
(mg/kg)

Location	Soil Type	Mean	Standard Deviation	Minimum	Maximum	Median	Reference
AFRICA							
Israel	uncontaminated soils	15					Nriagu, 1978
Egypt	uncontaminated soils	21					Nriagu, 1978
Cameroon	profiles	28.3		12.2	127		Ure and Berrow, 1982
Cameroon	uncontaminated soils	19					Nriagu, 1978
Madagascar	profiles	32		8	175		Ure and Berrow, 1982
Madagascar	uncontaminated soils	20					Nriagu, 1978
Nigeria	uncontaminated soils	18					Nriagu, 1978
Zambia	uncontaminated soils	20					Nriagu, 1978
South Africa	uncontaminated soils	12					Nriagu, 1978
mean		*21*		*10*	*151*		
min		*12*		*8*	*127*		
max		*32*		*12.2*	*175*		
ASIA							
China	profiles	25		<1	49		Ure and Berrow, 1982
Japan	uncontaminated soils	11					Nriagu, 1978
mean		*18*		*1*	*49*		
min		*11*		*1*	*49*		
max		*25*		*1*	*49*		
SOUTH PACIFIC							
Australia	uncontaminated soils	14					Nriagu, 1978
New Zealand	uncontaminated soils	16					Nriagu, 1978
mean		*15*					
min		*14*					
max		*16*					
ANTARCTICA	uncontaminated soils	8					Nriagu, 1978

TABLE 4.7 (continued)
LEAD CONCENTRATIONS IN SOILS
(mg/kg)

Location	Soil Type	Mean	Standard Deviation	Minimum	Maximum	Median	Reference
GLOBAL AVERAGES							
world	podzol	17					Nriagu, 1978
world	chernozen	16					Nriagu, 1978
world	tundra	13					Nriagu, 1978
world	desert	15					Nriagu, 1978
world	organic	44					Nriagu, 1978
world	solonetz	0.2					Nriagu, 1978
world	terra rosa	115					Nriagu, 1978
world	soils			10	25		Environment Canada, 1996b
world		17					Reimann and Caritat, 1998
world	soils/surficial materials			2	300	35	Frink, 1996
world	soils/surficial materials	10					Frink, 1996
world	soils/surficial materials					17	Frink, 1996
world	soils/surficial materials	19					Pais and Jones, 1997
world	soils/surficial materials	32		10	67		Pais and Jones, 1997
world	soils/surficial materials	20					Frink, 1996
world	soil	10					Frink, 1996
world	soil	10					Frink, 1996
world	soil	10					Frink, 1996
world	soil	10					Frink, 1996
mean		*22*		*7*	*131*		
min		*0.2*		*2*	*25*		
max		*115*		*10*	*300*		
Summary							
Canada		18		10.4	26.5		
North America		21		10.4	75.8		
Global		21		6.7	135		

TABLE 4.8
MERCURY CONCENTRATIONS IN SOILS
(Fg/kg)

Location	Soil Type	Mean	Standard Deviation	Minimum	Maximum	Median	Reference
CANADA							
Appalachian	A horizon only	94					McKeague et al., 1979
St. Lawrence Lowland	A horizon only	45					McKeague et al., 1979
Ontario	uncontaminated agricultural	80	80				Frank et al., 1976
Canada Shield	A horizon only	97		12	244		McKeague et al., 1979
Interior plains	A horizon only	33					McKeague et al., 1979
Cordilleran	A horizon only	48		34	76		McKeague et al., 1979
Canada	A horizons	22		<5	36		Ure and Berrow, 1982
Canada	topsoil	64		26	111		Ure and Berrow, 1982
Canada	topsoil	33		20	53		Ure and Berrow, 1982
Canada	cultivated and virgin soils	102		13	741		Steinnes, 1995
Canada	peat	60		10	110		Steinnes, 1995
Canada	plowed agricultural soils			5	130	40	Reimann and Caritat, 1998
mean		*62*		*16*	*188*		
min		*22*		*5*	*36*		
max		*102*		*34*	*741*		
UNITED STATES							
Eastern States	surface soils	147		10	3400		Steinnes, 1995
United States, East	0-3 inches			50	100		Ure and Berrow, 1982
Missouri	surface soils	39		<10	800		Steinnes, 1995
Colorado	surface soils	35		<10	420		Steinnes, 1995
Western States	surface soils	83		<10	4600		Steinnes, 1995
United States	surficial materials	81	2520	10	3400		Frink, 1996 (geometric)
United States	surface soils	112		<10	4600		Steinnes, 1995
United States		220		200	240		Ure and Berrow, 1982
United States	rural soils	110					Ure and Berrow, 1982
United States	surficial materials	96	2.53				Frink, 1996 (geometric)
United States	cropland and non-cropland	80		<50	1060		Steinnes, 1995
mean		*100*		*40*	*2069*		
min		*35*		*10*	*100*		
max		*220*		*200*	*4600*		

TABLE 4.8 (continued)
MERCURY CONCENTRATIONS IN SOILS
(Fg/kg)

Location	Soil Type	Mean	Standard Deviation	Minimum	Maximum	Median	Reference
EUROPE							
England	soil	250					Frink, 1996
England and Wales	topsoil			8	190	40	Ure and Berrow, 1982
Scotland	soil	120					Frink, 1996
Scotland	topsoil	138		90	260		Ure and Berrow, 1982
Scotland	topsoil	100		30	370		Ure and Berrow, 1982
Scotland	topsoil and profiles	130		<10	1710		Ure and Berrow, 1982
Scotland	profiles	94		10	200		Ure and Berrow, 1982
United Kingdom	cultivated and noncultivated	32		10	1780		Steinnes, 1995
Norway	forest soil, A horizon	188		20	550		Steinnes, 1995
Sweden	cultivated and noncultivated	60		4	920		Steinnes, 1995
Sweden		61		4	922		Ure and Berrow, 1982
Sweden	topsoil	70		20	290		Ure and Berrow, 1982
Sweden	topsoil	30					Ure and Berrow, 1982
France	topsoil	50					Ure and Berrow, 1982
France	soil	40					Frink, 1996
Italy	soil	400					Frink, 1996
Spain	soil	200					Frink, 1996
Austria	profiles	95		5	340		Ure and Berrow, 1982
Holland	topsoil	133		70	350		Ure and Berrow, 1982
mean		*122*		*23*	*657*		
min		*30*		*4*	*190*		
max		*400*		*90*	*1780*		
AFRICA							
Africa		23					Ure and Berrow, 1982
Africa, east and central	surface horizons	23		11	41		Steinnes, 1995
mean		*23*		*11*	*41*		
min		*23*		*11*	*41*		
max		*23*		*11*	*41*		
ASIA							
India	surface soils	20		3	689		Steinnes, 1995
Japan	A horizon	197		64	459		Ure and Berrow, 1982
mean		*109*		*34*	*574*		
min		*20*		*3*	*459*		
max		*197*		*64*	*689*		

TABLE 4.8 (continued)
MERCURY CONCENTRATIONS IN SOILS
(Fg/kg)

Location	Soil Type	Mean	Standard Deviation	Minimum	Maximum	Median	Reference
GLOBAL AVERAGES							
world	soil/surficial materials			10	500	60	Frink, 1996
world	soil/surficial materials	10					Frink, 1996
world	soil/surficial materials					56	Frink, 1996
world	soil/surficial materials	90					Pais and Jones, 1997
world	soil/surficial materials	300		10	1000		Pais and Jones, 1997
world	soil/surficial materials	100					Frink, 1996
world	soil	300					Frink, 1996
world	soil	30					Frink, 1996
world	soil	30					Frink, 1996
world		50					Reimann and Caritat, 1998
mean		*114*		*10*	*750*		
min		*10*		*10*	*500*		
max		*300*		*10*	*1000*		
Summary							
Canada		0.062		0.022	0.102		
North America		0.081		0.022	0.220		
Global		0.104		0.02	0.40		

TABLE 4.9
NICKEL CONCENTRATIONS IN SOILS
(mg/kg)

Location	Soil Type	Mean	Standard Deviation	Minimum	Maximum	Median	Reference
CANADA							
Appalachian	A horizon only	7					McKeague et al., 1979
New Brunswick	horizons			41	440		McKeague et al., 1979
St. Lawrence Lowland	A horizon only	18					McKeague et al., 1979
Quebec	agricultural soils	21.8		2.1	54		Health Canada, 1996
Ontario	agricultural soils	24.98	44.23	2	500		Health Canada, 1996
Ontario, Ottawa	agricultural soils	36		26	46		Health Canada, 1996
Ontario	parkland	13.5		<5	56		Health Canada, 1996
Ontario	rural soils	23		19	27		Health Canada, 1996
Ontario	A horizon	20.2		9.2	37.5		Chau and Kulikovsky-Cordeiro, 1995
Ontario	agricultural soils	15.9	16	1.3	119		Frank et al., 1976
Ontario	surface soils			10	34		McKeague et al., 1979
Canada Shield	A horizon only	12		2	26		McKeague et al., 1979
MB, SK, AB	agricultural soils	20	8	3	115		Health Canada, 1996
Alberta	agricultural high organic	27	14	<5	78		Health Canada, 1996
Alberta	rural parkland 0-5 cm	14.42	3.29	10	18		Health Canada, 1996
Alberta	agricultural low organic	15	8	<5	32		Health Canada, 1996
Alberta	agricultural 0-15 cm	20					Health Canada, 1996
Alberta	range of study means			15	24.9		Chau and Kulikovsky-Cordeiro, 1995
Interior plains	A horizon only	12					McKeague et al., 1979
Cordilleran	A horizon only	33		28	48		McKeague et al., 1979
Canada	topsoil	43		13	145		Ure and Berrow, 1982
mean		*21*		*12*	*106*		
min		*7*		*1.3*	*18*		
max		*43*		*41*	*500*		
UNITED STATES							
New England	surface soils	23.7					Frink, 1996
USA, SE	topsoil	55		8	247		Ure and Berrow, 1982
California		81		4.2	1523		Ure and Berrow, 1982
United States	topsoil	20		<5	700		Ure and Berrow, 1982
United States		13		5	27		Ure and Berrow, 1982
United States	agricultural surface soils	23.9	28.1	0.7	269	18.2	Frink, 1996 (arithmetic)
United States		26		2	77		Ure and Berrow, 1982
United States	surficial materials	13	2.6				Frink, 1996 (geometric)
United States	surficial materials	11	2.64	<5	700		Frink, 1996 (geometric)
mean		*30*		*4*	*506*		
min		*11*		*0.7*	*27*		
max		*81*		*8*	*1523*		

TABLE 4.9 (continued)
NICKEL CONCENTRATIONS IN SOILS
(mg/kg)

Location	Soil Type	Mean	Standard Deviation	Minimum	Maximum	Median	Reference
EUROPE							
England	soil	22.1					Frink, 1996
England and Wales	contam./uncontam. sites	26	17			24	McGrath, 1986
England and Wales	topsoil			4.4	228	26	Ure and Berrow, 1982
England and Wales	soil	24.5		0.8	439.5	22.6	McGrath, 1995
Wales	topsoil	29		9	142		Ure and Berrow, 1982
Wales	topsoil	20					Ure and Berrow, 1982
Scotland	soil	37.7					Frink, 1996
Scotland	profiles	20		6	60		Ure and Berrow, 1982
Scotland	profiles	53		4	150		Ure and Berrow, 1982
Finland	topsoil	86		<10	300		Ure and Berrow, 1982
Finland	forest soils 0-5 cm	0.04					Mukherjee, 1998
Finland	agricultural surface soils			<2	60.1	8.11	Reimann and Caritat, 1998
Finland	topsoil	24		13	46		Ure and Berrow, 1982
Denmark	topsoil	7.4					Ure and Berrow, 1982
Sweden	topsoil	8.7		0.1	64		Ure and Berrow, 1982
Sweden	soil	4.4					Frink, 1996
Denmark	soil	6.9					Frink, 1996
Norway	soil	61					Frink, 1996
Netherlands	soil	15.6					Frink, 1996
Spain	soil	28					Frink, 1996
Spain	profiles	52		3.2	957		Ure and Berrow, 1982
France	soil	35					Frink, 1996
Italy	soil	46					Frink, 1996
Austria	soil	20					Frink, 1996
Belgium	soil	33					Frink, 1996
Germany	profiles	111		20	300		Ure and Berrow, 1982
Germany	soil	15					Frink, 1996
Germany, beech forest	mineral layer	6					Heinrichs and Mayer, 1980
Germany, spruce forest	mineral layer	11					Heinrichs and Mayer, 1980
Poland	profiles	26		16	35		Ure and Berrow, 1982
Poland	profiles	13		4.4	31		Ure and Berrow, 1982
Poland	profiles	39		12	92		Ure and Berrow, 1982
Europe, central eastern	soil	18.5					Frink, 1996
USSR	profiles	31		10	70		Ure and Berrow, 1982
mean		*29*		*8*	*198*		
min		*0.04*		*0.1*	*31*		
max		*111*		*20*	*957*		
AFRICA							
Madagascar	profiles	74		3	530		Ure and Berrow, 1982
Cameroon	profiles	63		12	380		Ure and Berrow, 1982
Ghana	profiles	32		<10	200		Ure and Berrow, 1982
mean		*56*		*8*	*370*		
min		*32*		*3*	*200*		
max		*74*		*12*	*530*		

TABLE 4.9 (continued)
NICKEL CONCENTRATIONS IN SOILS
(mg/kg)

Location	Soil Type	Mean	Standard Deviation	Minimum	Maximum	Median	Reference
ASIA							
Burma	topsoil	31					Ure and Berrow, 1982
Burma	profiles	42		12	93		Ure and Berrow, 1982
China	profiles	51		11	180		Ure and Berrow, 1982
Japan	profiles	105		24	322		Ure and Berrow, 1982
mean		*57*		*16*	*198*		
min		*31*		*11*	*93*		
max		*105*		*24*	*322*		
SOUTH PACIFIC							
S.W. Pacific	topsoil	43					Ure and Berrow, 1982
Galapagos	profiles	120		20	270		Ure and Berrow, 1982
mean		*82*		*20*	*270*		
min		*43*		*20*	*270*		
max		*120*		*20*	*270*		
GLOBAL AVERAGES							
world	soil to 100 cm	16					Nriagu, 1980c
world	soil			0.2	450		Mukherjee, 1998
world		20					Reimann and Caritat, 1998
world	soil/surficial materials	40					Frink, 1996
world	soil/surficial materials			2	750	50	Frink, 1996
world	soil/surficial materials	40					Frink, 1996
world	soil/surficial materials					17	Frink, 1996
world	soil/surficial materials	19					Pais and Jones, 1997
world	soil/surficial materials	20		1	200		Pais and Jones, 1997
world	soil/surficial materials	50					Frink, 1996
world	soil	40					Frink, 1996
world	soil	40					Frink, 1996
world	soil	40					Frink, 1996
world	soil	40					Frink, 1996
mean		*33*		*1*	*467*		
min		*16*		*0.2*	*200*		
max		*50*		*2*	*750*		
Summary							
Canada		21		7	43		
North America		25		7	81		
Globla		48		0.04	120		

TABLE 4.10
ZINC CONCENTRATIONS IN SOILS
(mg/kg)

Location	Soil Type	Mean	Standard Deviation	Minimum	Maximum	Median	Reference
CANADA							
Nova Scotia	topsoil	54		14	108		Ure and Berrow, 1982
Nova Scotia	surface soil			23	86		McKeague et al., 1979
Nova Scotia	surface soil			247	593		McKeague et al., 1979
New Brunswick	normal soil			60	100		McKeague et al., 1979
New Brunswick		80		10	330		Ure and Berrow, 1982
Appalachian	A horizon only	74					McKeague et al., 1979
Ontario	agricultural surface soil	113	34	57	243		Environment Canada, 1996c
Ontario, SW	agricultural surface soil	88	28	40	163		Environment Canada, 1996c
Ontario, East	surface and subsurface			57	92		McKeague et al., 1979
Ontario	agricultural surface soil	53.5	34.3	4.6	162		Frank et al., 1976
Ontario, East	surface soil			51	106		McKeague et al., 1979
Ontario	surface soil			51	195		McKeague et al., 1979
St. Lawrence Lowland	A horizon only	41					McKeague et al., 1979
Canada Shield	A horizon only	41		8	99		McKeague et al., 1979
Canada, East		62		10	150		Ure and Berrow, 1982
Manitoba	topsoil	109		56	350		Ure and Berrow, 1982
Manitoba		56		7.5	137		Ure and Berrow, 1982
Manitoba	forested soils 0-5 cm	90	6				Environment Canada, 1996c
Manitoba	forested soils 5-10 cm	100	6				Environment Canada, 1996c
Manitoba	A and C horizons			41	127		McKeague et al., 1979
Alberta	Bl. Chernozem	98					Environment Canada, 1996c
Alberta	grey Luvisol	45					Environment Canada, 1996c
Alberta, NW	agricultural surface soil	94	47				Environment Canada, 1996c
Alberta, NW	agricultural surface soil	55					Environment Canada, 1996c
Alberta	Br. Chernozem	92					Environment Canada, 1996c
Alberta	Dk. Br. Chernozem	85					Environment Canada, 1996c
Alberta	glacial till			20	120		McKeague et al., 1979
Interior plains	A horizon only	52					McKeague et al., 1979
Interior plains	horizons			30	70		McKeague et al., 1979
Interior plains	0-15, 15-30 cm	122					McKeague et al., 1979
BC	topsoil	105					Ure and Berrow, 1982
BC	horizons			52	221		McKeague et al., 1979
BC	horizons			31	151		McKeague et al., 1979
Cordilleran	A horizon only	73		48	91		McKeague et al., 1979
ON, SK, BC	unspecified soil			33	160		McKeague et al., 1979
Canada	soil	74					Kiekens, 1995
Canada	plowed agricultural soils			20	835	72	Reimann and Caritat, 1998
Canada		110		56	164		Ure and Berrow, 1982
mean		*79*		*43*	*202*		
min		*41*		*4.6*	*70*		
max		*122*		*247*	*835*		

TABLE 4.10 (continued)
ZINC CONCENTRATIONS IN SOILS
(mg/kg)

Location	Soil Type	Mean	Standard Deviation	Minimum	Maximum	Median	Reference
UNITED STATES							
New England	surface soil	57.5					Frink, 1996
Georgia		32		4	143		Shuman, 1980
Florida				7	150		Shuman, 1980
Louisianna		42		7	150		Ure and Berrow, 1982
United States, SE	topsoil	70		15	103		Ure and Berrow, 1982
Nebraska		70		43	120		Ure and Berrow, 1982
Colorado		58		8	148		Ure and Berrow, 1982
California		81		28	212		Ure and Berrow, 1982
United States	surficial materials	36	1.89				Frink, 1996 (geometric)
United States	surficial materials	40	2.11	<5	2900		Frink, 1996 (geometric)
United States	uncultivated soil	51		<10	2000		ATSDR, 1994
United States	agricultural surface soil	56.5	37.2	<3	264	53	Frink, 1996 (arithmetic)
United States	topsoil	54		<25	2000		Ure and Berrow, 1982
United States		148		14	320		Ure and Berrow, 1982
mean		*61*		*14*	*709*		
min		*32*		*3*	*103*		
max		*148*		*43*	*2900*		

TABLE 4.10 (continued)
ZINC CONCENTRATIONS IN SOILS
(mg/kg)

Location	Soil Type	Mean	Standard Deviation	Minimum	Maximum	Median	Reference
EUROPE							
England	topsoil	117		42	284		Ure and Berrow, 1982
England	topsoil			23	184	67	Ure and Berrow, 1982
England	soil	78.2					Kiekens, 1995
England and Wales	topsoil			5	816	77	Ure and Berrow, 1982
England and Wales	uncontam./contam. sites	103	111			87	McGrath, 1986
Wales	topsoil	70		14	229		Ure and Berrow, 1982
Wales	topsoil	73					Ure and Berrow, 1982
Scotland	profiles	60		20	100		Ure and Berrow, 1982
Scotland	soil	58		0.7	987		Kiekens, 1995
Sweden	topsoil	59		4	310		Ure and Berrow, 1982
Sweden	soil	182		100	318		Kiekens, 1995
Finland	agricultural surface soil			<1	121	22.3	Reimann and Caritat, 1998
Denmark	topsoil	31					Ure and Berrow, 1982
Denmark	soil	7		7	76		Kiekens, 1995
Norway	soil	60		40	100		Kiekens, 1995
Netherlands	soil	72.5		9	1020		Kiekens, 1995
Spain	soil	59		10	109		Kiekens, 1995
Spain	profiles	144		28	420		Ure and Berrow, 1982
Spain	topsoil	45		7	125		Ure and Berrow, 1982
Portugal	soil	58.4					Kiekens, 1995
Portugal	profiles	42		<5	93		Ure and Berrow, 1982
Italy	soil	89					Kiekens, 1995
France	soil	16		5	38		Kiekens, 1995
Belgium	soil	57		14	130		Kiekens, 1995
Austria	soil	65		36	8900		Kiekens, 1995
Germany	soil	83		13	492		Kiekens, 1995
Germany, beech forest	mineral soils	38					Heinrichs and Mayer, 1980
Germany, spruce forest	mineral soils	32					Heinrichs and Mayer, 1980
Poland	profiles	79		32	235		Ure and Berrow, 1982
Poland	profiles	47		2	175		Ure and Berrow, 1982
Poland	profiles	28		3.5	90		Ure and Berrow, 1982
USSR, European	topsoil	40					Ure and Berrow, 1982
USSR	topsoil	45					Ure and Berrow, 1982
USSR	topsoil	50		3.5	139		Ure and Berrow, 1982
mean		*64*		*18*	*645*		
min		*7*		*0.7*	*38*		
max		*182*		*100*	*8900*		

TABLE 4.10 (continued)
ZINC CONCENTRATIONS IN SOILS
(mg/kg)

Location	Soil Type	Mean	Standard Deviation	Minimum	Maximum	Median	Reference
AFRICA							
Israel	profiles	75		16	169		Ure and Berrow, 1982
Israel	profiles	53		14	92		Ure and Berrow, 1982
Israel	profiles	107		48	214		Ure and Berrow, 1982
Egypt	topsoil	76		39	99		Ure and Berrow, 1982
Nigeria	profiles	42		9	84		Ure and Berrow, 1982
Nigeria	topsoil	19		7.5	39		Ure and Berrow, 1982
mean		*62*		*22*	*116*		
min		*19*		*7.5*	*39*		
max		*107*		*48*	*214*		
ASIA							
India	topsoil	71		40	131		Ure and Berrow, 1982
India	topsoil	61		28	126		Ure and Berrow, 1982
India	topsoil	37		5	95		Ure and Berrow, 1982
India	topsoil	34		6.9	131		Ure and Berrow, 1982
India	topsoil	59		33	90		Ure and Berrow, 1982
India		79		49	111		Ure and Berrow, 1982
India	topsoil	59		53	65		Ure and Berrow, 1982
China	profiles	85		12	250		Ure and Berrow, 1982
Japan	profiles	108		55	205		Ure and Berrow, 1982
mean		*66*		*31*	*134*		
min		*34*		*5*	*65*		
max		*108*		*55*	*250*		
SOUTH PACIFIC							
Papua-New Guinea	profiles	53		27	92		Ure and Berrow, 1982
Australia	topsoil	16		1.5	100		Ure and Berrow, 1982
Australia	topsoil	62		5	180		Ure and Berrow, 1982
Australia	profiles	40		11	86		Ure and Berrow, 1982
New Zealand	profiles	56		14	200		Ure and Berrow, 1982
mean		*45*		*12*	*132*		
min		*16*		*1.5*	*86*		
max		*62*		*27*	*200*		
SOUTH AMERICA							
Galapagos	profiles	65		22	170		Ure and Berrow, 1982
Brazil	topsoil	72		5	131		Ure and Berrow, 1982
mean		*68.5*		*13.5*	*150.5*		
min		*65*		*5*	*131*		
max		*72*		*22*	*170*		

TABLE 4.10 (continued)
ZINC CONCENTRATIONS IN SOILS
(mg/kg)

Location	Soil Type	Mean	Standard Deviation	Minimum	Maximum	Median	Reference
GLOBAL AVERAGES							
world	soil/surficial materials	50					Frink, 1996
world	soil/surficial materials			1	900	90	Frink, 1996
world	soil/surficial materials	50					Frink, 1996
world	soil/surficial materials					36	Frink, 1996
world	soil/surficial materials	60					Pais and Jones, 1997
world	soil/surficial materials			10	300		Pais and Jones, 1997
world	soil/surficial materials	50					Frink, 1996
world	soil	50					Frink, 1996
world	soil	50					Frink, 1996
world	soil	50					Frink, 1996
world	normal soil			40	58		Shuman, 1980
world		70					Reimann and Caritat, 1998
mean		*54*		*17*	*419*		
min		*50*		*1*	*58*		
max		*70*		*40*	*900*		
Summary							
Canada		79		41	122		
North America		70		32	148		
Global		65		7	182		

TABLE 4.11

CONCENTRATIONS OF METALS IN SEA WATER

(ng/L)

Cd	Cu	Hg	Ni	Pb	Zn	Location	Source	Comments
100 (70 to 710)	500	30	1700	30	30	"Typical"	Brewer, 1975	Given the age & high numbers, suspect data
up to 0.7	<10 to 20			<10 to 60		Between Dakar & Bermuda, 0.2 to 0.4 m depth	Duce et al, 1976	
		6 - 11 41 122 45 - 78				open ocean continental slope continental shelf Long Island Sound	Fitzgerald, 1976	Northwest Atlantic; older data and therefore suspect
44	390		230		1070	North Atlantic (Nova Scotia)	Bewers & Yeats, 1977	
	96 ± 13					Atlantic (off NW Africa), 1 m depth	Moore, 1978	
0.16	33		130		4.7	North Pacific Gyre	Bruland 1980	
0.23 #1.8 #0.35	78 ± 7 91 ± 13 65 ± 7		140 ± 6 120 ± 6 140 ± 12		4.0 ± 1.3 20 ± 3.4	Sargasso Sea	Bruland & Franks, 1983	
6.1 ± 9.6	75 ± 34		130 ± 42			North Atlantic & North Pacific surface water	Boyle et al, 1981	240 to 265 samples
				17.4 to 31 mean = 22		Western North Atlantic surface	Schaule & Patterson, 1981	
				34		Sargasso Sea 0.2 m depth	Schaule & Patterson, 1983	anthropogenic effects?
25 22 24	510 470 330		580 510 390	50 46 56	670 700 720	Between Sweden & Denmark	Magnusson & Westerlund, 1983	Values seem high
		total: 2.3 ± 1.0 reactive: 1.4 ± 0.7				North Atlantic (near Greenland & Iceland)	Ólafsson, 1983	
	100			35	4	Atlantic	Weisel et al, 1984	
	60			10	5	Pacific	Weisel et al, 1984	
		1 to 3 0.5 to 4.5 1.2 to 3.2 0.3 to 0.7				North sea North Atlantic North Atlantic Pacific Ocean	Lindqvist, 1985	Summarized from other sources; may include deep water data

unless otherwise specified, ### ± ## represents mean ± standard deviation

TABLE 4.11 (continued)

CONCENTRATIONS OF METALS IN SEA WATER (ng/L)

Cd	Cu	Hg	Ni	Pb	Zn	Location	Source	Comments
		total: 10.9 ± 4.1 inorganic: 6.1 ± 2.0				Western North Pacific, surface water	Suzuki & Sugimura, 1985	
	242130131				33	Peru	Heaton, 1986	
	7189				4	Sargasso Sea	Heaton, 1986	
		0.6 to 0.8 0.4				near Berumuda Tasman Sea	Gill & Fitzgerald, 1988	Surface water samples
	76 ± 25		110 ± 24			Sargasso Sea 1 m depth	Jickells & Burton, 1988	Salinity = 3.647%
	64		140			Sargasso Sea 1 m depth	Jickells & Burton, 1988	Salinity = 3.599%
0.2	62			10	5	'bulk sea water' estimates	Dick, 1991	from sources considered best by author
		0.32 (total) 0.18 ± 0.19 (elemental)				North Atlantic, mixed ocean layer	Mason et al, 1995	
		0.2 to 2.0				Normal ocean concentrations	Fitzgerald et al, 1998	
87 (60 - 136)				140 (98 - 174)		Mediterranean 10 m depth	Migon & Nicolas, 1998	Mean & range; Na = 10.8 x 10^6 ng/L; may be some anthropogenic inputs
3.1±0.05		0.80±0.05		9.1±0.05		Kongsfjord (near Norway) surface samples	Pongratz & Heumann, 1998	9 samples
3.2		1.1		9.3		Antarctic seawater	Pongratz & Heumann, 1999	
0.16 3.1 25	33 89 510	9.1 28 56	0.18 1.6 2.5	110 140 580	4 5 720	*Minimum* *Median* *Maximum*	Global Values	excluding suspect data (age or anthropogenic)
0.16 0.35 6.1	33 75 91	10 28 35	0.7 1.1 1.4	110 140 140	4 4 20	*Minimum* *Median* *Maximum*	Canada/North America values	excluding suspect data (age or anthropogenic)

TABLE 4.12

ESTIMATES OF GLOBAL SEA SALT FLUX

ESTIMATED SEA SALT FLUX	SOURCE	COMMENTS
8 $ng/cm^2/h$ (wind speed = 3.4 m/s) 170 $ng/cm^2/h$ (wind speed = 6.5 m/s) 410 $ng/cm^2/h$ (wind speed = 10 m/s)	Buat-Ménard, 1984	
2.89×10^{12} kg/year	Monahan, 1986	for sea surface from 70º N to 70º S; associated w/ water droplets 0.8 to 10 Fm radius (based on modelling)
1×10^{12} kg/year	Duce et al, 1976	
3×10^{12} kg/year (geometric mean; range 1×10^{12} kg/year to 1×10^{13} kg/year)	Weisel et al, 1984	
1×10^{12} kg/year 2.89×10^{12} kg/year 1×10^{13} kg/year	*Minimum* *Most Probable* *Maximum*	

TABLE 4.13

CONCENTRATIONS OF METALS IN THE SURFACE MICROLAYER

Cd	Cu	Pb	Zn	Location	Source	Comments
0.5 to 2.1ng/L	60 to 1800 ng/L	60 to 250 ng/L		Between Dakar & Bermuda	Duce et al, 1976	Surface microlayer
4800 ng/L (3900 - 25000)		2600 ng/L (1200 - 6500)		Mediterranean surface microlayer	Migon & Nicolas, 1998	Mean & range; may be some anthropogenic inputs
EF = 857	EF = 25	EF = 10	EF = 45		Migon & Nicolas, 1998	Enrichment from bulk sea to surface microlayer

EF (enrichment factor) is the ratio of the concentration in the surface microlayer to the concentration in bulk sea water.

TABLE 4.14

ESTIMATES OF SEA WATER TO SEA SALT ENRICHMENT (EF_{sea})

Cd	Cu	Ni	Pb	Zn	Source	Comments
	200			200	Duce et al, 1976	Naragansett Bay
	800 (200 - 1900)		4000 (300 - 20 000)	20 000 (<2000 - 300 000)	Weisel et al, 1984	Sargasso Sea
200			2000 - 5000	200	Heaton, 1986 (by others)	Naragansett Bay
4000			2000 - 5000	10 000	Heaton, 1986 (by others)	Sargasso Sea
	540			245 000 100 000 37 000	Heaton, 1986	Sargasso Sea
	150 430 550 250			820 840 780 390 360 320 460	Heaton, 1986	Peru (according to Fitzgerald et al, 1983, there is high biological activity in Peru upwelling)
1 200 4000	1 430 800	1 1 10	1 3250 5000	1 800 245000	*Minimum* *Median* *Maximum*	

EF_{sea} is defined as the ratio of the element to sodium in sea salt aerosol divided by the ratio of the element to sodium in sea water. To use this, multiply by the element to sodium ratio in sea water ([Na] is, on average, 1.06×10^7 Fg/L), then multiply by the Na transport rate to atmosphere (use 35% of sea salt flux, based on Weisel et al, 1984 & Duce et al, 1976).

TABLE 4.15
SULPHUR DIOXIDE EMISSIONS FROM VOLCANOES

Sulphur Dioxide Emissions (t/yr)	**Active/Passive Emissions**	**Source**
1.52×10^7 1.4×10^7 1.0×10^6	total passive active	Berresheim and Jaeschke 1983
1.3×10^7 4.5×10^6 9×10^6 3.5×10^6	total passive passive active	Hinkley *et al.* 1999
1.6×10^7 8.0×10^6 8.0×10^6	total passive active	Varekamp and Buseck 1986
5.0×10^7	total	Lambert *et al.* 1988
4.5×10^6 1.52×10^7 5.0×10^7		*Minimum* *Most Likely* *Maximum*

TABLE 4.16 METAL : SULPHUR DIOXIDE RATIOS IN VOLCANIC EMISSIONS

TABLE 4.16a CADMIUM : SULPHUR DIOXIDE RATIOS IN VOLCANIC EMISSIONS

LOCATION		CADMIUM CONCENTRATION ug/m3	SO2 CONCENTRATION ug/m3	CADMIUM : SO2 RATIO	SOURCE
Etna	plume	0.092	10000	9.20E-06	Buat-Menard and Arnold, 1978
Etna	vent	30	1000000	3.00E-05	
Kilauea				2.00E-05	Olmez et al., 1986
Mt. St. Helens		0.0012	53.5	2.20E-05	Phelan et al., 1982
Kilauea, 1996				1.57E-04	Hinkley, 1999
Kilauea, 1991				1.78E-05	Hinkley, 1999
Kilauea	skylights			1.20E-04	Hinkley, 1999
Indonesia				6.00E-06	Hinkley, 1999
Indonesia				4.40E-05	Hinkley, 1999
New Zealand				2.70E-05	Le Cloarec et al., 1992
mean				4.53E-05	
median				2.45E-05	
minimum				6.00E-06	
maximum				1.57E-04	

TABLE 4.16b COPPER : SULPHUR DIOXIDE RATIOS IN VOLCANIC EMISSIONS

LOCATION		COPPER CONCENTRATION ug/m3	SO2 CONCENTRATION ug/m3	COPPER : SO2 RATIO	SOURCE
Etna	plume	3.2	10000	3.20E-04	Buat-Menard and Arnold, 1978
Etna	vent	243	1000000	2.30E-05	Buat-Menard and Arnold, 1978
Kilauea				6.50E-05	Olmez et al., 1986
New Zealand				8.49E-04	Le Cloarec et al., 1992
Kilauea, 1996				1.85E-04	Hinkley, 1999
Kilauea, 1991				4.20E-05	Hinkley, 1999
Kilauea	skylights			4.40E-04	Hinkley, 1999
Indonesia				6.00E-05	Hinkley, 1999
Indonesia				6.40E-04	Hinkley, 1999
mean				2.92E-04	
median				1.85E-04	
minimum				2.30E-05	
maximum				8.49E-04	

TABLE 4.16c LEAD : SULPHUR DIOXIDE RATIOS IN VOLCANIC EMISSIONS

LOCATION		LEAD CONCENTRATION ug/m3	SO2 CONCENTRATION ug/m3	LEAD : SO2 RATIO	SOURCE
Etna	plume	1.2	10000	1.20E-04	Buat-Menard and Arnold, 1978
Etna	vent	78	1000000	7.80E-05	Buat-Menard and Arnold, 1978
New Zealand				3.75E-04	Le Cloarec et al., 1992
Kilauea				6.00E-05	Hinkley, 1999
Kilauea	skylights			1.21E-04	Hinkley, 1999
Indonesia				4.20E-04	Hinkley, 1999
Indonesia				2.80E-04	Hinkley, 1999
	plume			1.33E-04	Patterson and Settle, 1987
	fumerole			5.75E-06	Patterson and Settle, 1987
mean				1.77E-04	
median				1.21E-04	
min				5.75E-06	
max				4.20E-04	

TABLE 4.16d MERCURY : SULPHUR DIOXIDE RATIOS IN VOLCANIC EMISSIONS

LOCATION		MERCURY CONCENTRATION ug/m3	SO2 CONCENTRATION ug/m3	MERCURY : SO2 RATIO	SOURCE
Etna	plume	0.25	10000	2.50E-05	Buat-Menard and Arnold, 1978
Etna	vent	0.5	1000000	5.00E-07	Buat-Menard and Arnold, 1978
Kilauea	passive	0.147	38000	3.90E-06	Olmez et al., 1986
Kilauea	passive	19	93600	2.00E-04	Olmez et al., 1986
Etna	total, plume			6.30E-06	Dedeurwaerder et al., 1982
Poas	fumerole			3.00E-06	Ballentine et al., 1982
Arenal	plume			6.00E-04	Ballentine et al., 1982
Nicaragua	passive			3.00E-05	Stoiber et al., 1982
Mt. St. Helens	passive			1.20E-03	Stoiber et al., 1982
Colima, Mexico	active			3.60E-06	Varekamp and Buseck, 1986
Mt. Shasta	active			3.90E-05	Varekamp and Buseck, 1986
Mt hood	active			7.10E-06	Varekamp and Buseck, 1986
St. Helens	active			1.05E-05	Varekamp and Buseck, 1986
St Helens	active			3.00E-03	Varekamp and Buseck, 1986
Etna	fumerole			2.00E-06	Varekamp and Buseck, 1986
Kilauea	main vent			5.10E-04	Siegel and Siegel, 1984
mean				3.53E-04	
median				1.78E-05	
minimum				5.00E-07	
maximum				3.00E-03	

TABLE 4.16e NICKEL : SULPHUR DIOXIDE RATIOS IN VOLCANIC EMISSIONS

LOCATION		NICKEL CONCENTRATION ug/m3	SO2 CONCENTRATION ug/m3	NICKEL : SO2 RATIO	SOURCE
Etna	plume	0.33	10000	3.30E-05	Buat-Menard and Arnold, 1978
Etna	vent	6.6	1000000	6.60E-06	Buat-Menard and Arnold, 1978
Kilauea				2.90E-04	Olmez et al., 1986
mean				1.10E-04	
median				3.30E-05	
minimum				6.60E-06	
maximum				2.90E-04	

TABLE 4.16f ZINC : SULPHUR DIOXIDE RATIOS IN VOLCANIC EMISSIONS

LOCATION		ZINC CONCENTRATION ug/m3	SO2 CONCENTRATION ug/m3	ZINC : SO2 RATIO	SOURCE
Etna	plume	10	10000	1E-03	Buat-Menard and Arnold, 1978
Etna	hot vent	78	1000000	8E-05	Buat-Menard and Arnold, 1978
Kilauea	vent			3E-05	Olmez et al., 1986
Mt. St. Helens		0.26	53.5	5E-03	Phelan et al., 1982
Kilauea,, 1996				2E-04	Hinkley, 1999
Kilauea,, 1991				3E-04	Hinkley, 1999
Kilauea	skylights			2E-04	Hinkley, 1999
Indonesia				6E-05	Hinkley, 1999
Indonesia				6E-03	Hinkley, 1999
				9E-05	Kotra et al., 1983
mean				1E-03	
median				2E-04	
minimum				3E-05	
maximum				6E-03	

TABLE 4.17
METAL : SULPHUR DIOXIDE RATIOS - SUMMARIES

	Metal : Sulphur Dioxide Ratios		
	Minimum	**Most Probable**	**Maximum**
Cadmium	6×10^{-6}	4.5×10^{-5}	1.6×10^{-4}
Copper	2.3×10^{-5}	2.9×10^{-4}	8.50×10^{-4}
Lead	5.8×10^{-6}	1.8×10^{-4}	4.2×10^{-4}
Mercury	5×10^{-7}	3.5×10^{-4}	3.0×10^{-3}
Nickel	6.6×10^{-6}	1.1×10^{-4}	2.9×10^{-4}
Zinc	3.0×10^{-5}	1.2×10^{-3}	5.8×10^{-3}

TABLE 4.18

BIOME-SPECIFIC BURNING DATA

BIOME	TOTAL AREA (ha)	AREA BURNED (ha/y)	ANNUAL % OF TOTAL AREA BURNED	TOTAL BIOMASS (tonnes/ha)	BIOMASS BURNED (tonnes/ha)	% OF BIOMASS BURNED	TOTAL BIOMASS BURNED (Mt/y)	SOURCE	COMMENTS
Boreal Forest			4% 9% 16.6%					Wein, 1993	Northern AB taiga Northern MA taiga Chinese taiga
Boreal Forest						0.17% of burned + unburned		Crossley, 1977	AB
Boreal Forest	13252900	6645	0.05%	387	73	19		Taylor & Sherman, 1996	BC Engelman spruce & subalpine fir; 100% wild
Boreal Forest	12857000	8002	0.06%	294	55	19		Taylor & Sherman, 1996	BC sub-boreal spruce and pine-spruce; 100% wild
Boreal Forest	15260097	102627	0.67%	196	53	27		Taylor & Sherman, 1996	BC boreal white and black spruce; 60% wild
Boreal Forest								Cofer et al, 1996	Bor Forest, Russia
Boreal Forest			0.4% - 2%					Bergeron et al, 1998	based on fire cycles
Boreal Forest		5 - 10 x 10^6 avg range 2 x 10^6 to 2.2 x 10^7		34 (Bor Forest, Russia)	25			Cofer et al, 1996	wildfires 90% of area burned
Boreal Forest		5641350			25		141	Stocks, 1991	Based on data for Canada, Alaska, Scandinavia & estimates for USSR
Boreal Forest							140	Hao & Ward, 1993	100% wild
Boreal Barrens				67.45 39.73 59.80				Penner et al, 1997	Taiga Plains forest Taiga Shield forest Hudson Plains forest
Boreal Forest				71.8 78.33 83.49				Penner et al, 1997	Boreal Shield forest Boreal Plains forest Boreal Cordillera forest
Boreal Forest		2 x 10^6 (Canada)			25 range: 5 - 100		50 (Canada)	Garrett, 1995	Canadian forest
Coastal/Mountain Forest	2633900	950	0.036%	263	45	17		Taylor & Sherman, 1996	BC montane spruce; 80% wild
Coastal/Mountain Forest	7802200	9410	0.12%	355	70	20		Taylor & Sherman, 1996	BC spruce willow birch; 100% wild
Coastal/Mountain Forest			6.7% to 33% 2% - 3.3%					Trabaud et al, 1993	Australian forests Mediterranean forests (his.)
Coastal/Mountain Forest	5240500	765	0.015%	379	71	19		Taylor & Sherman, 1996	BC interior cedar hemlock; 100% wild

TABLE 4.18 (continued)

BIOME-SPECIFIC BURNING DATA

BIOME	TOTAL AREA (ha)	AREA BURNED (ha/y)	ANNUAL % OF TOTAL AREA BURNED	TOTAL BIOMASS (tonnes/ha)	BIOMASS BURNED (tonnes/ha)	% OF BIOMASS BURNED	TOTAL BIOMASS BURNED (Mt/y)	SOURCE	COMMENTS
Coastal/Mountain Forest	162800	12	0.007%	621	105	17		Taylor & Sherman, 1996	BC coastal Douglas fir; 100% wild
Coastal/Mountain Forest	67066182			30.6 to 40.6				Leenhouts, 1998	US (averaged)
Coastal/Mountain Forest	4375400	6342	0.14%	187	38	20		Taylor & Sherman, 1996	BC interior Douglas fir; 60% wild
Coastal/Mountain forest				10.031	8.427	84		Kauffman et al, 1994	Brazilian dry forest, prescribed fire
Coastal/Mountain Forest	4119100	500	0.012%	647	127	20		Taylor & Sherman, 1996	BC mountain hemlock; 100% wild
Coastal/Mountain Forest	9995100	2436	0.024%	900	166	18		Taylor & Sherman, 1996	BC coastal western hemlock; 100% wild
Coastal/Mountain Forest				238.28 152.14				Penner et al, 1997	Pacific Maritime forest Montane Cordillera forest
Desert	34916819			2.1 to 11.9				Leenhouts, 1998	US (averaged)
Forests (boreal + temperate)		$5.8 - 6.8 \times 10^6$					280	Andreae, 1991	3.8 million ha wildfires, remaining prescribed
Forest (general)		$10 - 15 \times 10^6$				20		Levine et al, 1999	estimated combustion efficiency, area burned (boreal & temperate)
Grassland	187244725			6.8 to 9.7				Leenhouts, 1998	US (averaged)
Grassland	16.9×10^6 80.6×10^6 77.1×10^6 52.6×10^6		5% - 15% 25% 50% 60% - 80%	0.5 - 2.5 2 - 4 3 - 6 4 - 8		65% - 95%		Menaut et al, 1991 & Lacaux et al, 1993	West African savanna
Grassland		81×10^6			3.15			Liousse et al, 1996	African savanna
Grassland			1/3 total 1/8 total					Trollope, 1996	high rainfall savanna low rainfall svanna (Kruger National Park)
Grassland							1190	Andreae, 1991	Savanna (global)
Grassland				7.128	7.126	100		Kauffman et al, 1994	Brazilian grassland, prescribed fire
Grassland	2.6×10^9	1.5×10^9	58%				7.9	Goldammer, 1991	Upper limit for savanna area burned (pantropical)
Grassland				6.2 - 7.9				USDA, 1996	palmetto prairie
Grassland							767 2428 71 425	Lacaux et al, 1993	American savanna African savanna Asian savanna Australian savanna

TABLE 4.18 (continued)

BIOME-SPECIFIC BURNING DATA

BIOME	TOTAL AREA (ha)	AREA BURNED (ha/y)	ANNUAL % OF TOTAL AREA BURNED	TOTAL BIOMASS (tonnes/ha)	BIOMASS BURNED (tonnes/ha)	% OF BIOMASS BURNED	TOTAL BIOMASS BURNED (Mt/y)	SOURCE	COMMENTS
Grassland	1011 x 10^6		50%	6.06 (aboveground)		80%	2520 (2000-3000)	Lacaux et al, 1993	African savanna
Grassland		500 x 10^6 (grasslands included)				20		Levine et al, 1999	Estimated combustion efficiency
Mixed/Deciduous Forest				83.68 90.83				Penner et al, 1997	Atlantic Maritime forest Mixedwood Plains forest
Mixed/Deciduous Forest	290741307			12 to 15.8				Leenhouts, 1998	US (averaged)
Mixed Forest				37.2 26.6				USDA, 1996	Great Lakes pine forest
Mixed (temperate) forest							130	Hao & Ward, 1993	110 wild, 20 prescribed
Rain Forest							130 (100-150)	Lacaux et al, 1993	African forest
Rainforest							9.5	Scholes et al, 1996	African evergreen forest
Rainforest					2 to 5			Cofer et al, 1996	Tropical forests
Shrub/Chaparral				33.6 3.44				USDA, 1996	pocosin cypress savana
Shrub/Chaparral	662100	615	9.3%	95	24	25		Taylor & Sherman, 1996	BC ponderosa pine/bunch grass; 90% wild
Shrub/Chaparral			2% - 10% 6.6% - 10%					Trabaud et al, 1993	Australian shrublands Mediterranean maquis (his.)
Shrub/Chaparral	191345718			12.2 to 15.5				Leenhouts, 1998	US (averaged)
Shrub/Chaparral		500 x 10^6 (grasslands included)				20		Levine et al, 1999	Estimated combustion efficiency
Tundra				42.97 56.41				Penner et al, 1997	Southern Arctic forest Taiga Cordillera forest
Tundra	17489200	7188		62	13	21		Taylor & Sherman, 1996	BC tundra; 100% wildfires
Wetlands	5527451			6.7 to 43.3 avg: 30.5				Leenhouts, 1998	US
Boreal Forest (summary)		2 x 10^6 5.6 x 10^6 2 x 10^7			525100				*Minimum* *Most Likely* *Maximum*
Grassland & Shrubland (summary)		5 x 10^8 1.34 x 10^9 1.5 x 10^9			0.5 3.2 7.1				*Minimum* *Most Likely* *Maximum*

TABLE 4.19

METAL CONCENTRATIONS IN SMOKE PARTICLES

(% by mass unless otherwise specified)

BIOME	CADMIUM	COPPER	LEAD	MERCURY	NICKEL	ZINC	SOURCE	COMMENTS
Forest	0.1% (flaming) 0.03% (smoldering)	<0.02% (flaming & smoldering)	0.15% (flaming) 0.03% (smoldering)		<0.02% (flaming & smoldering)	0.2% (flaming) <0.02% (smoldering)	Ward & Hardy, 1991	$PM_{2.5}$ from conifer logging slash fire in US (concentrations are % by weight of particles, estimated from graph)
Forest, Grassland			not detected	not detected			Ward et al, 1992	detection limit less than 0.1% by weight (estimated from graph) Brazilian cerrado & forest
Grassland						0.0032 g/kg dry matter burned (0.00036 - 0.0089)	Echalar et al, 1995	Ivory Coast savanna; median & range; emission factor (g metal per kg dry matter burned)
Grassland						0.0012 g/kg dry matter burned (0.00055 to 0.0047)	Echalar et al, 1995	South African savanna; median & range; emission factor (g metal per kg dry matter burned)
Grassland, Shrub/Chaparral		0.0069% ± 0.005%	0.0096% ± 0.0086%			0.015% ± 0.006%	Artaxo et al, 1993	Particulate (median size < 2.0 Fm) from biomass burning in Brazil (brush & savanna fire); metals may be from other sources too?
Grassland						0.033% 0.033% 0.015% 0.000026%	Cachier et al, 1996	back fire (savanna) head fire posthead fire smoldering (tree)
Grassland	<0.008% flaming; <0.007% smoldering	0.0028% flaming <0.003% smoldering	0.0064% flaming 0.0025% smoldering		<0.002% flaming <0.003% smoldering	0.045% flaming 0.0102% smoldering	Maenhaut et al, 1996b	Particles collected above South African savanna prescribed fires; lead may be due to remobilization of deposited material from other sources
Shrub/Chaparral		0.01% ± 0.01%	0.34% ± 0.21%		0	0.15% ± 0.8%	Ward & Hardy, 1991	data from 3 prescribed burns in California chaparral
Shrub/Chaparral		slightly less than conifer slash (above)	2.5 x conifer slash (i.e. 0.38% flaming, 0.075% smoldering)		not detected	1.5 x conifer slash (i.e. 0.3% flaming)	Ward & Hardy, 1991	$PM_{2.5}$ from chaparral fire in western US (concentrations are % by weight of particles, estimated from graph). Lead content may be influenced by deposition from outside?
Forest (Summary)	0.03 0.065 0.1	0 0.02 0.02	0.03 0.09 0.15	0 (assumed)	0 0.02 0.02	0.02 0.1 0.2		*Minimum* *Most Likely* *Maximum*
Grassland & Shrubland (Summary)	0.007 0.0075 0.008	0.0028 0.0066 0.01	0.0025 0.135 0.38	0 (assumed)	0 0.002 0.003	0.0102 0.075 0.3		*Minimum* *Most Likely* *Maximum*

TABLE 4.20

BIOME-SPECIFIC FIRE-RELATED PARTICULATE EMISSIONS DATA

BIOME	PARTICLE EMISSION RATE (g/kg dry matter)	PARTICLE SIZE	SOURCE	COMMENTS
Boreal Forest	18.2 ± 21.1 20.3 ± 20.7	$PM_{2.0}$ TPM	Radke et al, 1991	Prescribed; pine & spruce (Ontario)
Boreal Forest	22	$PM_{2.5}$	Taylor & Sherman, 1996	Black spruce wildfire
Boreal Forest (+ other forest)	20 ± 15 15 ± 10 20 ± 15	TPM	Cofer et al, 1996	North American boreal and temperate forests
Coastal/Mountain	32.9 (range: 25 - 40.8) 23.6 (range: 10.0 - 39.0) 6.6 (range: 6.0 - 7.0)	TPM TPM $PM_{2.5}$	Vose et al, 1996	SE US pine forest wild fire US conifer prescribed fires “
Coastal/Mountain Forest	1331	$PM_{2.5}$ TPM	Taylor & Sherman, 1996	Fir/pine (Oregon) wildfire
Coastal/Mountain Forest	26.4 ± 13.6 32.5 ± 17.1	$PM_{2.0}$ TPM	Radke et al, 1991	Wildfire, fir and hemlock (US)
Grassland	5.2 5.6 5.1 6.6	$PM_{2.5}$	Scholes et al, 1996	African infertile savanna African fertile savanna African infertile grassland African fertile grassland
Grassland	11.4 ± 4.6 (flaming) 69 ± 25 (smoldering)	TPM (aerosol)	Cachier et al, 1995	African savanna
Grassland	13 (range: 7.5 - 22)	TPM	Vose et al, 1996	US prescribed grassland fires
Grassland	7.2 ± 3.8 >6 3.9 ± 2.0 10.0 ± 8.5 6.4 ± 3.2 >10 5.4 ± 2.2 >11 3.7 ± 1.6 >6 2.1 ± 0.4 >3 3.7 ± 0.5 -- 3.6 ± 1.2 -- 5 10	$PM_{2.5}$ TPM $PM_{2.5}$ TPM $PM_{2.5}$ TPM $PM_{2.5}$ TPM $PM_{2.5}$ TPM $PM_{2.5}$ TPM $PM_{2.5}$ TPM $PM_{2.5}$ TPM $PM_{2.5}$ TPM	Andreae et al, 1996	African moist, infertile savanna African moist, infertile savanna African arid, fertile savanna African moist and semiarid savanna African moist, infertile savanna African grasslands African sugar can field Brazilian cerrado Grassland & savanna (average)
Grassland	8.5 5.0	TPM	Cachier et al, 1996	Savanna
Grassland	10	TPM	Ward & Hardy, 1991	US cured grass; mainly prescribed
Grassland	5.12 ± 2.28	$PM_{2.5}$	Ward et al, 1996	Savanna fires (Africa)
Grassland	43.8 47.9	$PM_{2.0}$ TPM	Radke et al, 1991	Prescribed; wheat stubble (US)
Grassland	6.5 (range: 2.9 - 16) 7.0 (range: 1.2 - 16)	TPM	Echalar et al, 1995	South African savanna Ivory Coast savanna (median + range)
Mixed/Deciduous Forest	11.3	$PM_{2.5}$	Scholes et al, 1996	African dry forest
Mixed/Deciduous	23 (range: 17.49 - 29.0) 13.5 (range: 7.45 - 19.9) 15.1 (range: 6.9 - 18.7) 9.8 (range: 6.0 - 16)	TPM $PM_{2.5}$ TPM $PM_{2.5}$	Vose et al, 1996	US mixed wood prescribed fires US hardwood prescribed fires
Mixed Forest	36.4	$PM_{3.5}$	Hobbs et al, 1996	Idaho wildfire
Mixed Forest	2.5 - 90 appr. 75	TPM	McMahon, 1983	Prescribed forest fires Wild forest fires (estimated)
Mixed Forest	222429	$PM_{3.5}$	Hobbs et al, 1996	Logged area (prescribed burns)

TABLE 4.20 (continued)

BIOME-SPECIFIC FIRE-RELATED PARTICULATE EMISSIONS DATA

BIOME	PARTICLE EMISSION RATE (g/kg dry matter)	PARTICLE SIZE	SOURCE	COMMENTS
Mixed/Deciduous Forest	5.5 ± 3.5 6.9 ± 4.3 12.9 ± 9.1 13.3 ± 9.1	$PM_{2.0}$ TPM $PM_{2.0}$ TPM	Radke et al, 1991	Prescribed; birch & poplar (Ontario) Prescribed; birch, poplar, mixed hardwoods (Ontario)
Rainforest	27	TPM	Cachier et al, 1996	African tree fires (smoldering)
Rainforest	12.3	$PM_{2.5}$	Scholes et al, 1996	African evergreen forest
Raoinforest	20	TPM	Levine et al, 1999	Tropical rain forests
Shrub/Chaparral	7.9 ± 5.7 10.8 ± 6.0 14.3 ± 7.3 17.6 ± 7.9 15.5 ± 6.5 17.7 ± 7.0 19.5 ± 12.1 29.3 ± 16.5	$PM_{2.0}$ TPM $PM_{2.0}$ TPM $PM_{2.0}$ TPM $PM_{2.0}$ TPM	Radke et al, 1991	Prescribed; standing black stage, sumac & chamise (US) Prescribed; standing chaparral, chamise (US) Prescribed; standing chaparral, chamise (US) Wildfire; pine, brush & fir (US)
Shrub/Chaparral	16.5 (range: 7.5 - 62.5)	TPM	Vose et al, 1996	US prescribed chaparral fires
Shrub/Chaparral	5.0 7.7	$PM_{2.5}$	Scholes et al, 1996	African shrublands African fynbos
Shrub/Chaparral	15	TPM	Ward & Hardy, 1991	US chaparral, gallberry, etc., mainly prescribed
Shrub/Chaparral	12.2 to 21.1 5.7 to 7.7	TPM $PM_{2.5}$	Ward & Hardy, 1989	prescribed California chaparral fires
Wetlands	5.1	$PM_{2.5}$	Scholes et al, 1996	African wetland
Forest (Summary)	5 20 35	TPM		*Minimum* *Most Likely* *Maximum*
Grassland & Shrubland (Summary)	5 10 15	TPM		*Minimum* *Most Likely* *Maximum*

$PM_{x.x}$ - particles with an aerodynamic diameter less than or equal to x.x Fm
TPM - total particulate matter

TABLE 4.21

METAL CONCENTRATIONS IN PLANTS AND ASH

(ppm unless otherwise specified)

MATERIAL	CADMIUM	COPPER	LEAD	MERCURY	NICKEL	ZINC	SOURCE	COMMENTS
Ash from pine, spruce & fir twigs	7.6 (2 to 20) 5.6 (2 to 20)*	190 (150 to 300)	210 (20 to 2000) 53 (20 to 1000)*		23 (<5 to 70)	1300 (200 to 2000)	Curtin et al, 1974	Geometric mean & range. Data collected from sites with anomalously high metals (Colorado & Idaho); * indicates data excluding sites with high Cd & Pb
Ash from pine, spruce & fir needles	3.4 (<2 to 10) 3.1 (<2 to 10)*	92 (10 to 200)	32 (2 to 2000) 10 (2 to 100)*		14 (<5 to 30)	1000 (300 to 3000)	Curtin et al, 1974	Geometric mean & range. Data collected from sites with anomalously high metals (Colorado & Idaho); * indicates data excluding sites with high Cd & Pb
Lodgepole pine ash	<2	345	51 (increases at higher temp.)		59 (increases at higher temp.)	2678 (decreases at higher temp.)	Etiégni & Campbell, 1991	Results from sawdust burned at 538ºC (within range for flaming phase of fires)
mosses lichen mushrooms				0.080 ± 0.053 0.075 ± 0.025 0.030 ± 0.014 0.037 ± 0.013 0.14 ± 0.080			Rasmussen et al, 1991	Southern Ontario; high Hg in nearby lakes (natural?)
Assorted trees				0.014 ± 0.0032 0.0095 ± 0.0028 0.014 ± 0.0072 0.0074 ± 0.0027 0.010 ± 0.0090			Rasmussen et al, 1991	Southern Ontario; high Hg in nearby lakes (natural?)
smoke - US conifer logging slash	0.1% (flaming) 0.03% (smoldering)	<0.02% (flaming & smoldering)	0.15% (flaming) 0.03% (smoldering)		<0.02% (flaming & smoldering)	0.2% (flaming) <0.02% (smoldering)	Ward & Hardy, 1991	$PM_{2.5}$ from logging slash fire in US (concentrations are % by weight of particles, estimated from graph)
Ash - horse chestnut leaves	0.197 ± 0.106 (0.085 - 0.489)	129 ± 71 (27.9 - 333)	294 ± 212 (31.5 - 1100)			299 ± 121 (155 - 708)	Kim & Fergusson, 1994	Trees in 6 parks in Christchurch, New Zealand (some were near roads). Mean ± standard deviation and range.
trees wildflowers aq. macrophytes club mosses moss lichen mushrooms aquatic algae aquatic bacteria				24.2 - 28.7ng/g 30.1 ng/g 44.0 - 63.0 ng/g 80.6 - 103.3 ng/g 41.2 - 139.9 ng/g 24.3 - 58.4 ng/g 104.0 ng/g 56.9 - 150 ng/g 63.0 ng/g			Rasmussen, 1994b	Ontario (Canada's Shield); range of median values for several species

TABLE 4.21 (continued)

METAL CONCENTRATIONS IN PLANTS AND ASH

(ppm unless otherwise specified)

MATERIAL	CADMIUM	COPPER	LEAD	MERCURY	NICKEL	ZINC	SOURCE	COMMENTS
conifers	0.025 (twigs/foliage) 0.02 (total)						Garrett, 1995	Based on biogeochemical studies; poplars and aspens generally similar
Black spruce bark spruce needle Lichen				100 - 200 ng/g 20 ng/g 400 - 1100 ng/g			Zhang et al, 1995a	Quebec boreal forest; numbers estimated from graph
Black spruce wood				13 - 37 ng/g			Zhang et al, 1995b	data from Quebec boreal forest
Bark Wood Ash	0.55 ± 0.34 0.21 ± 0.14 0.46 ± 0.56	5.3 ± 1.0 1.3 ± 0.4 40 ± 16	0.74 ± 0.37 1.1 ± 0.46 3.6 ± 2.0		0.73 ± 0.18 2.6 ± 2.0 26 ± 12	160 ± 57 34 ± 15 790 ± 400	McIlveen, 2000	Firewood in Wawa area (Ontario) - paper birch. Mean ± standard deviation.

TABLE 4.22

ESTIMATES OF COSMIC FLUX
(tonnes/year)

ESTIMATED COSMIC FLUX	SOURCE	YEAR OF ORIGINAL ESTIMATE	COMMENTS
3×10^6	Bruns, 1999	1952	
4×10^7	Bruns, 1999	1958	
4×10^7	Bruns, 1999	1965	
$<1 \times 10^5$	Bruns, 1999	1966	
6×10^4 to 1×10^5	Bruns, 1999	1968	
1×10^4	Bruns, 1999	1975	
3.65×10^3	Hindley, 1976	1976	Value used in Nriagu's work; calculation method not specified; author mentions flux could factor of 10 higher
8×10^4	Bruns, 1999	1986	
7.8×10^8	Bruns, 1999	1987	Based on luminosities
7.8×10^4	Bruns, 1999	1987	
4×10^5	Bruns, 1999	1987	
4.9×10^4 to 5.6×10^4	Bruns, 1999	1988	Love & Brownlee (1993) believe this is best geochemical estimate
3.65×10^5	Lebedinets & Kurbanmuradov, 1992	1992	Best fit of model with light scattering data; assumes average density = 1
2×10^4 to 6×10^4	Love & Brownlee, 1993	1993	Particles with mass between 10^{-9} g and 10^{-4} g only; based on craters on a metal plate in orbit
1.9×10^5	Bruns, 1999	1997	
2×10^5	Hughes, 1997	1997	Based on concentration in space and movement of Earth
4×10^4 8×10^4 4×10^5	*Minimum* *Median* *Maximum*		Minimum, median and maximum of post-1980 data, excluding luminosity estimate

TABLE 4.23

METAL CONCENTRATIONS IN INTERPLANETARY DUST (mg/kg)

CADMIUM	COPPER	LEAD	MERCURY	NICKEL	ZINC	COMMENTS	SOURCE
	126			11000	312	Typical CI chondrite	Arndt et al., 1996
				10300	303	Typical CI chondrite	Ganapathy & Brownlee 1979
	264 error: 1.15[a]			8610 error: 1.09[a]	724 error: 2.55[a]	44 meteorites classified as chondrites (geometric mean)	Arndt et al., 1996
	175 error: 1.13[a]			7650 error: 1.17[a]	46.2 error: 1.32[a]	12 meteorites classified as low-Zn (geometric mean)	Arndt et al., 1996
	44.3 error: 1.57[a]			228 error: 1.59[a]	338 error: 1.72[a]	11 meteorites classified as low-Ni (geometric mean)	Arndt et al., 1996
	11800 error: 2.85[a]			1850 error: 1.58[a]	3150 error: 1.88[a]	6 meteorites classified as nonsystematic (geometric mean)	Arndt et al., 1996
	13700 ± 31100			4120 ± 21700	6120 ± 29000	arithmetic mean ± std. dev (all particles studied combined)	Arndt et al., 1996
				13100 ± 807	699 ± 129	0.07 Fg interplanetary dust particle (mean ± std. dev.)	Ganapathy & Brownlee 1979
				6650 ± 679	973 ± 129	0.11 Fg interplanetary dust particle (mean ± std. dev.)	Ganapathy & Brownlee 1979
				50000 to 500000		Based on National Academy of Sciences, 1975. *Nickel.*	Schmidt and Andren, 1980
		0.45 (0.019 to 5.3)				Ordinary chondrites (31) mean and range	Nriagu, 1978
		1.95 (0.9 to 4.6)				Carbonaceous chondrites (13) mean and range	Nriagu, 1978
		2.82 (1.8 to 4.2)				Enstate chondrites (5) mean and range	Nriagu, 1978
		0.44 (0.07 to 0.63)				Achondrites (7) mean and range	Nriagu, 1978
		5.9 (1.4 to 515)				Troilite (30) mean and range	Nriagu, 1978

a - error factor; range is (geometric mean/error) to (geometric mean * error)

4.23 (continued)

METAL CONCENTRATIONS IN INTERPLANETARY DUST (mg/kg)

CADMIUM	COPPER	LEAD	MERCURY	NICKEL	ZINC	COMMENTS	SOURCE
		0.17 (0.098 to 0.40)				Octahedrites etc. (15) mean and range	Nriagu, 1978
		0.03 (0.02 to 0.04)				Hexahedrites (3) mean and range	Nriagu, 1978
720 ± 160						Based on reported CI chondrite Cd/Zn ratio of 2.3 ± 0.5 and CI chondrite Zn concentration from Arndt et al, 1996	Warren et al, 1999
1.0; 0.40-1.11 (2)	127 ± 14 (3)	3 (1)	61.9; 2.4-213 (6)	10200 (7)	390; 330-450 (2)	C1 chondrites	from Mason, 1971
0.44; 0.012-1.16 (4)	116 ± 12 (7)	2.3; 0.9-4.6 (3)	4.3; 1.57-6.82 (4)	12400 (11)	180 (2)	C2 chondrites	
0.20; 0.039-0.38 (4)	108 ± 17 (10)		2.5; 0.69-7.3 (6)	13800 (16)	120; 105-130 (6)	C3 chondrites	Chapter authors:
0.041; 0.015-0.12 (5)	91 ± 20 (28)	0.24; 0.08-0.46 (6)	0.074-13.9 (25)	16900 (70)	51; 28-89 (8)	H chondrites (Bronzite)	Cadmium: Buseck
0.05; 0.007-0.087 (7 L & LL)	93 ± 16	0.37; 0.06-0.51 (7)	0.015-5.99 (28)	11500 (125)	58; 8-102 (15)	L chondrites (Hypersthene)	Copper: Goles
	81 ± 40		0.55; 0.24-0.84 (2)	9100 (12)		LL chondrites (Amphoterite)	Lead: Oversby
					400; 350-460 (2)	E3 chondrites	Mercury: Reed
2.1; <0.01-3.3 (2)	193 ± 12	2.6; 2.2-3 (2)	0.62; 0.004-1.52 (4)	18100 (3)	85 (1)	E4 chondrites (Enstatite, Type I)	Nickel: Moore
0.042 (1)	110 ± 60 (4 E5 & E6)		0.53; 0.16-0.80 (4 E5 & E6)	17100 (2)		E5 chondrites (Enstatite, Intermed.)	Zinc: Moore
0.10; 0.082-0.12 (3)				15300 (6)	17; 8-28 (4)	E6 chondrites (Enstatite, Type II)	
0.17; <0.010-0.33 (2)						Ca-poor achondrites:	
	13 ± 6 (5)		0.054 (1)			Aubrite	
		0.46; 0.36-0.57 (2)		160 (3)	15; 5-25 (2)	Enstatite	
			0.28; 0.121-0.43 (2)	75 (2)	34; 3-63 (2)	Hypersthene	
				670 (2)		Chassignite	
	11 ± 1 (2)			1300 (6)		Ureilites	
0.044; 0.022-0.065 (2)						Ca-rich achondrites	
			2.51 (1)			Angrite	
0.98; 0.18-1.79 (2)	12 ± 2 (2)		0.23 (1)	550 (2)	84 (1)	Nakhlite	
	3 ± 3 (5)		0.66 (1)	13 (1)	37 (1)	Howardite	
	6 ± 5 (7)	0.5; 0.4-0.7 (2)	3.4; 0.078-9.12 (5)	13 (6)	5; 2-11 (3)	Eucrites	
						Stony-iron meteorites	
0.03; <0.004-0.056 (2)				42600 (12)		Mesosiderites: total	
				82000 (9)		Mesosiderites: metal	
0.19; 0.13-0.33 (2)				53 (12)		Pallasites: olivine	
				105000 (23)	<1 (1)	Pallasites: metal	
				46600 (10)		Pallasites: total	
0.03; 0.0085-0.056 (7)						Iron meteorites	
					0.48 - 16	Hexahedrites	
					<1 - 61	Octahedrites	
mean; range	mean ± std. dev.	mean; range	mean; range (just range for some classes)	mean	mean; range (just range for irons)	( ) indicates number of meteorites analyzed	

TABLE 4.23 (continued)

METAL CONCENTRATIONS IN INTERPLANETARY DUST (mg/kg)

CADMIUM	COPPER	LEAD	MERCURY	NICKEL	ZINC	COMMENTS	SOURCE
0.041 1 2.1	81 127 264	0.24 0.53 3	0.53 61.9 61.9	8610 10500 18100	17 335 724	*Minimum* *Most Probable* *Maximum*	Based on CI chondrites and minimum and maximum mean values in other chondrites

TABLE 4.24

PUBLISHED MERCURY VAPOUR FLUX ESTIMATES FROM VEGETATION, WATER AND SOIL

LOCATION	SOIL	VEGETATION	FRESHWATER	MARINE	SOURCE	COMMENTS
		0.175 ± 0.10 ng/h/cm^2			Kozuchowski & Johnson, 1978	reeds at contaminated site; mercury in sediment = 10.4 ± 4.2 ppm
		0.035 ± 0.027 ng/h/cm^2			Kozuchowski & Johnson, 1978	reeds at contaminated site; mercury in sediment = 3.15 ± 0.7 ppm
		0.009 ± 0.011 ng/h/cm^3			Kozuchowski & Johnson, 1978	reeds at uncontaminated site; mercury in sediment = 0.08 ± 0.07 ppm
Hawaii		0.001 - 39.5 Fg/kg/h vascular plants			Kama & Siegel, 1980	soil Hg = 26.8 ± 12.9 Fg/kg
Various		0.8 Fg/kg/h vascular 0.26 Fg/kg/h non-vascular			Siegel et al., 1980	
	0.02 - 0.03 Fg/m^2/h 0.06 Fg/m^2/h 10°C 0.12 Fg/m^2/h 25°C 0.8 Fg/m^2/h 0.16 Fg/m^2/h		9.5 Fg/m^2/h Yukon, NWT 17.0 Fg/m^2/h other provinces (corrected for ice cover: 3.2 and 10.2, respectively)	0.13 Fg/m^2/h oceanic shelf 0.063 Fg/m^2/h open ocean	Environment Canada, 1981b	summarized from other sources; based on data predating ultraclean lab methodology
Equatorial Pacific				3.0 - 54 Fg/m^2/y global: 2.3 kt/y	Fitzgerald, 1986	
Equatorial Pacific				4.4 - 78.7 Fg/m^2/y annual: 0.32 ± 0.26 kt/y global: 2.9 ± 1.8 kt/y	Kim & Fitzgerald, 1986	global estimate based on Hg flux being directly proportional to productivity
	0.1 pg/m^2/s --> 400 t/y				Varekamp & Busek, 1986	from another source
Sweden Eagle Lake (US)	0.1 - 1.4 ng/m^2/h		3.2 - 20 ng/m^2/h 4.5 ng/m^2/h (average)		Schroeder et al. 1989	September measurements
Little Rock Lake, Wisconsin			pH 6.1: 1.5 ± 0.9 Fg/m^2/y pH 4.7: 0.7 ± 0.3 Fg/m^2/y		Vandal et al, 1991	fluxes larger in August than October
	50 ng/m^2/h forest soils (modelled)				Lindberg et al, 1992	based on results of model; predicted canopy would be deposition sink
US forest floor	emission: 7.5 ± 7.0 ng/m^2/h deposition: -2.2 ± 2.4 ng/m^2/h				Kim et al, 1995	background Hg emissions; 30 emission events and 9 deposition events

TABLE 4.24 (continued)

PUBLISHED MERCURY VAPOUR FLUX ESTIMATES FROM VEGETATION, WATER AND SOIL

LOCATION	SOIL	VEGETATION	FRESHWATER	MARINE	SOURCE	COMMENTS
US (Walker Branch Watershed)	5 - 10 ng/m^2/h	30 - 80 ng/m^2/h			Lindberg, 1995	
US soils	7.5 ± 7.0 ng/m^2/h background 86 ± 72 ng/m^2/h contaminated		<1-3 ng/m^2/h		Lindberg et al., 1995	both emission & deposition occurred for background, but emission more frequent & greater magnitude
US contaminated site	5 to 125 Fg/m^2/h (contaminated soil)				Gustin et al., 1996	
US forest floor Lake (Sweden)	9.0 ± 5.7 ng/m^2/h		 6.8 ± 5.6 ng/m^2/h		Meyers et al., 1996	background Hg emissions
Arctic lakes			0.08 ng/m^2/h 0.26 ng/m^2/h 0.56 ng/m^2/h 0.52 ng/m^2/h		Amyot et al., 1997b	data from August
Ranger Lake (US)			0.04 - 1.3 ng/m^2/h		Amyot et al., 1997a	
roasted cinnabar bank mineralized forest soil roasted cinnabar bank mineralized soil low mineralized soil rural; near Pisa garden (all data from Mediterranean)	26 - 10000 ng/m^2/h -0.5 - 6 ng/m^2/h 80000 - 110000 ng/m^2/h 5000 ng/m^2/h 200 ng/m^2/h 1.5 - 8 ng/m^2/h 3 - 30 ng/m^2/h				Ferrara et al., 1997	180 Fg/g Hg in soil 0.5 Fg/g Hg in soil 700 Fg/g Hg in soil 9 Fg/g Hg in soil 0.7 Fg/g Hg in soil 0.6 Fg/g Hg in soil 1 Fg/g Hg in soil temperature effects noted
deciduous tree bark deciduous tree foliage oak forest soils	 7.1 - 16.1 ng/m^2/h	1.2 - 10.8 ng/m^2/h 2.7 - 5.5 ng/m^2/h			Hanson et al., 1997	
Walker Branch 1 Walker Branch 2 Watson Forest Nelson Field (shade) Nelson Field (sunlight) Barn Field (shade) Barn Field (sunlight)	6.98 ± 1.91 ng/m^2/h 2.00 ± 0.67 ng/m^2/h 2.70 ± 0.48 ng/m^2/h 1.21 ± 0.29 emisson (N=5) -0.66 ± 0.52 deposition (N=9) 12.47 ± 5.44 ng/m^2/h 16.80 ± 2.56 ng/m^2/h 44.83 ± 5.23 ng/m^2/h				Carpi & Lindberg, 1998	soil temperature & solar radiation effects noted Soil Hg = 469 ± 75 ng/g Soil Hg = 61 ± 19 ng/g Soil Hg = 111 ± 14 ng/g

TABLE 4.24 (continued)

PUBLISHED MERCURY VAPOUR FLUX ESTIMATES FROM VEGETATION, WATER AND SOIL

LOCATION	SOIL	VEGETATION	FRESHWATER	MARINE	SOURCE	COMMENTS
US (contaminated site)		Hg flux ($ng/m^2/h$) = -11.2 + 5.59 ln[soil Hg]			Leonard et al., 1998b	$r^2 = 0.97$ mean of several plant species; adjusted to irradiance of 1500 Fmol/m^2/s
mature hardwood (US) young pines (US) forest floor (Sweden)	 1 $ng/m^2/h$; 2 Fg/m^2/y (0.8-3.6)	37 $ng/m^2/h$; 70 Fg/m^2/y (15 - 120) 18 $ng/m^2/h$; 30 Fg/m^2/y (2 - 60)			Lindberg et al., 1998	mean hourly, mean annual and 90% CI
methylated metal release by 10 species of marine algae (polar; collected near Norway)				5.4±4.0 pg/g/d MeHg in 9 sp. (ND in 1sp.) 3.9±3.5 pg/g/d Me_2Hg in 8 sp. (ND in 2 sp.)	Pongratz & Heumann, 1998	
Thunder Bay granite Clyde Forks background Thunder Bay shale Nevada geothermal site Clyde Forks sulphide anomaly	0.6 $ng/m^2/h$ 23 $ng/m^2/h$ 35 $ng/m^2/h$ 300 $ng/m^2/h$ 1928 $ng/m^2/h$				Rasmussen et al., 1998b	0.02 Fg/g Hg in soil 0.2 Fg/g Hg in soil 1 Fg/g Hg in soil 9.5 Fg/g Hg in soil 200 Fg/g Hg in soil (mean values; most estimated from graph)
	1 - 10 $ng/m^2/h$ forest soil			2000 t/y	Schroeder & Munthe, 1998	(more fluxes in table; check to ensure we have all)
	15 t/y US forest soil 80 t/y US agricultural/open 15 t/y US mercuriferous soil	40 t/y (US only)	freshwater + coastal at least 50% of terrestrial		Nriagu, 1999	
Antarctic Ocean (51ºS to 71º S) Arctic Ocean (Greenland, 64ºN to 79ºN) Atlantic Ocean (38ºN to 58ºS)				0.21 kt/y 0.24 kt/y 1.9 kt/y	Pongratz & Heumann, 1999	(Me_2Hg; assumes all Me_2Hg in marine atmosphere is from bacteria)

TABLE 4.24 (continued)

PUBLISHED MERCURY VAPOUR FLUX ESTIMATES FROM VEGETATION, WATER AND SOIL

LOCATION	SOIL	VEGETATION	FRESHWATER	MARINE	SOURCE	COMMENTS
Global			0.04 ng/m^2/h 2.5 ng/m^2/h 20 ng/m^2/h		*Minimum* *Mean* *Maximum*	Based on post-1985 data
Canada/North America			0.04 ng/m^2/h 1 ng/m^2/h 3 ng/m^2/h		*Minimum* *Mean* *Maximum*	Based on post-1985 data for United States and Arctic
Global Equatorial Pacific				2.9 ± 1.8 kt/y 0.32 ± 0.26 kt/y	*Mean and Standard Deviation*	as per Kim and Fitzgerald, 1986
Form of equation Slope Intercept	log [Flux (ng/m^2/h)] = slope * log[soil Hg (Fg/g)] + intercept 0.868 ± 0.14 -1.1326 ± 0.47	Flux (ng/m^2/h) = slope * ln[soil Hg(Fg/g) + intercept 5.59 -11.2			*Regressoion Equation*	soil: based on post-1985 data vegetation: as per Leondard et al., 1998b

TABLE 5.1

FLUX ESTIMATES DUE TO SOIL PARTICLES

Flux of metal (kg/yr) = flux of soil particles (kg/km^2/yr) * element concentration (mg/kg) * land surface area considered (km^2) * 10^{-6} kg/mg

			MEAN	5th PERCENTILE	50th PERCENTILE	95th PERCENTILE
CANADA	Soil Particle Flux (kg/yr)		4.3×10^{10}	8.1×10^{9}	3.6×10^{10}	1.1×10^{11}
	Flux of Metal (kg/yr)	- Cd	2.7×10^{4}	3.9×10^{3}	2.1×10^{4}	7.4×10^{4}
		- Cu	2.6×10^{6}	3.0×10^{5}	1.8×10^{6}	7.6×10^{6}
		- Pb	7.9×10^{5}	1.4×10^{5}	6.4×10^{5}	2.0×10^{6}
		- Hg	2.7×10^{3}	4.4×10^{2}	2.2×10^{3}	6.8×10^{3}
		- Ni	1.0×10^{6}	1.6×10^{5}	8.0×10^{5}	2.7×10^{6}
		- Zn	3.5×10^{6}	6.1×10^{5}	2.8×10^{6}	8.8×10^{6}
NORTH AMERICA	Soil Particle Flux (kg/yr)		8.2×10^{11}	1.7×10^{11}	7.3×10^{11}	1.8×10^{12}
	Flux of Metal (kg/yr)	- Cd	5.0×10^{5}	7.9×10^{4}	4.0×10^{5}	1.3×10^{6}
		- Cu	4.9×10^{7}	6.4×10^{6}	3.7×10^{7}	1.4×10^{8}
		- Pb	4.5×10^{7}	5.7×10^{6}	3.3×10^{7}	1.2×10^{8}
		- Hg	8.9×10^{4}	1.4×10^{4}	7.1×10^{4}	2.2×10^{5}
		- Ni	3.1×10^{7}	4.9×10^{6}	2.4×10^{7}	8.1×10^{7}
		- Zn	3.0×10^{7}	4.9×10^{6}	2.3×10^{7}	7.7×10^{7}
GLOBAL	Soil Particle Flux (kg/yr)		3.2×10^{13}	5.9×10^{12}	2.7×10^{13}	7.4×10^{13}
	Flux of Metal (kg/yr)	- Cd	2.4×10^{7}	3.0×10^{6}	1.8×10^{7}	6.9×10^{7}
		- Cu	2.0×10^{9}	2.4×10^{8}	1.4×10^{9}	5.5×10^{9}
		- Pb	1.7×10^{9}	2.0×10^{8}	1.2×10^{9}	4.9×10^{9}
		- Hg	5.5×10^{6}	7.0×10^{5}	4.1×10^{6}	1.5×10^{7}
		- Ni	1.8×10^{9}	2.1×10^{8}	1.3×10^{9}	4.9×10^{9}
		- Zn	2.7×10^{9}	3.5×10^{8}	2.0×10^{9}	7.4×10^{9}

TABLE 5.2

FLUX ESTIMATES DUE TO SEA SALT

Flux of metal (kg/yr) = sea salt flux (kg/y) * [element concentration in sea water (ng/L) / sodium concentration in sea water (ng/L)] * EF_{sea} * fraction of sodium in sea salt

			MEAN	5th PERCENTILE	50th PERCENTILE	95th PERCENTILE
	Sea Salt Flux (kg/y)		3.9×10^{10}	1.6×10^{10}	3.7×10^{10}	6.8×10^{10}
CANADA	Flux of Metal (kg/yr)	- Cd	4.0×10^{3}	2.4×10^{2}	2.3×10^{3}	1.3×10^{4}
		- Cu	3.5×10^{4}	7.8×10^{3}	3.0×10^{4}	7.8×10^{4}
		- Pb	8.6×10^{4}	1.9×10^{4}	7.4×10^{4}	1.9×10^{5}
		- Hg	1.4×10^{0}	5.5×10^{-1}	1.3×10^{0}	2.5×10^{0}
		- Ni	6.7×10^{2}	1.5×10^{2}	5.4×10^{2}	1.6×10^{3}
		- Zn	9.8×10^{5}	5.7×10^{4}	6.7×10^{5}	3.0×10^{6}
	Sea Salt Flux (kg/y)		1.3×10^{11}	5.4×10^{10}	1.2×10^{11}	2.3×10^{11}
NORTH AMERICA	Flux of Metal (kg/yr)	- Cd	1.3×10^{4}	7.8×10^{2}	7.8×10^{3}	4.4×10^{4}
		- Cu	1.2×10^{5}	2.7×10^{4}	1.0×10^{5}	2.6×10^{5}
		- Pb	2.9×10^{5}	6.3×10^{4}	2.5×10^{5}	6.4×10^{5}
		- Hg	4.6×10^{0}	1.8×10^{0}	4.2×10^{0}	8.3×10^{0}
		- Ni	2.2×10^{3}	4.9×10^{2}	1.8×10^{3}	5.4×10^{3}
		- Zn	3.3×10^{6}	1.8×10^{5}	2.2×10^{6}	9.9×10^{6}
GLOBAL	Sea Salt Flux (kg/yr)		4.7×10^{12}	2.0×10^{12}	4.4×10^{12}	8.2×10^{12}
	Flux of Metal (kg/yr)	- Cd	2.0×10^{6}	1.3×10^{5}	1.3×10^{6}	6.7×10^{6}
		- Cu	1.3×10^{7}	2.0×10^{6}	1.0×10^{7}	3.6×10^{7}
		- Pb	1.3×10^{7}	2.7×10^{6}	1.1×10^{7}	3.1×10^{7}
		- Hg	2.2×10^{2}	6.4×10^{1}	2.0×10^{2}	4.5×10^{2}
		- Ni	1.7×10^{5}	3.0×10^{4}	1.3×10^{5}	4.6×10^{5}
		- Zn	3.1×10^{9}	7.6×10^{7}	1.7×10^{9}	1.1×10^{10}

TABLE 5.3

FLUX ESTIMATES DUE TO VOLCANIC EMISSIONS

Flux of metal (kg/yr) = flux of sulfur dioxide (kg/yr) * element to sulfur dioxide ratio

			MEAN	5^{th} PERCENTILE	50^{th} PERCENTILE	95^{th} PERCENTILE
GLOBAL	Flux of Metal (kg/yr)	- Cd	1.6×10^6	3.8×10^5	1.4×10^6	3.8×10^6
		- Cu	9.0×10^6	2.1×10^6	7.7×10^6	2.0×10^7
		- Pb	4.7×10^6	1.1×10^6	4.1×10^6	1.0×10^7
		- Hg	2.6×10^7	3.9×10^6	2.1×10^7	6.6×10^7
		- Ni	3.2×10^6	7.4×10^5	2.7×10^6	7.0×10^6
		- Zn	5.4×10^7	1.0×10^7	4.5×10^7	1.3×10^8

TABLE 5.4

FLUX ESTIMATES DUE TO FIRE

Flux of metal (kg/yr) = area burned per year (ha/yr) * biomass consumed per area (tonnes/ha) * total particulate matter emitted (kg/tonne) * element concentration in particulate (mg/kg) 10^{-6} kg/mg

			MEAN	5th PERCENTILE	50th PERCENTILE	95th PERCENTILE
CANADA	Fire Particle Flux (kg/yr)		6.4×10^{7}	2.7×10^{7}	5.9×10^{7}	1.2×10^{8}
	Flux of Metal (kg/yr)	- Cd	2.2×10^{4}	5.9×10^{3}	1.8×10^{4}	5.4×10^{4}
		- Cu	6.2×10^{3}	2.1×10^{3}	5.3×10^{3}	1.4×10^{4}
		- Pb	8.5×10^{4}	2.7×10^{4}	7.6×10^{4}	1.8×10^{5}
		- Hg	2.3×10^{2}	6.9×10^{1}	2.0×10^{2}	4.9×10^{2}
		- Ni	4.6×10^{3}	1.0×10^{3}	3.5×10^{3}	1.2×10^{4}
		- Zn	7.6×10^{4}	2.4×10^{4}	6.7×10^{4}	1.6×10^{5}
NORTH AMERICA	Fire Particle Flux (kg/yr)		5.6×10^{7}	1.4×10^{7}	4.5×10^{7}	1.4×10^{8}
	Flux of Metal (kg/yr)	- Cd	3.5×10^{4}	6.5×10^{3}	2.7×10^{4}	9.0×10^{4}
		- Cu	7.2×10^{3}	1.2×10^{3}	5.4×10^{3}	2.0×10^{4}
		- Pb	5.3×10^{4}	1.3×10^{4}	4.1×10^{4}	1.3×10^{5}
		- Hg	9.2×10^{1}	2.4×10^{1}	7.2×10^{1}	2.3×10^{2}
		- Ni	7.1×10^{3}	1.0×10^{3}	5.2×10^{3}	1.9×10^{4}
		- Zn	6.1×10^{4}	1.3×10^{4}	4.5×10^{4}	1.6×10^{5}
GLOBAL	Fire Particle Flux (kg/yr)		5.6×10^{10}	2.4×10^{10}	5.3×10^{10}	9.8×10^{10}
	Flux of Metal (kg/yr)	- Cd	1.3×10^{7}	4.4×10^{6}	1.1×10^{7}	3.0×10^{7}
		- Cu	4.7×10^{6}	1.8×10^{6}	4.3×10^{6}	9.1×10^{6}
		- Pb	8.3×10^{7}	2.4×10^{7}	7.3×10^{7}	1.8×10^{8}
		- Hg	2.5×10^{5}	6.6×10^{4}	2.1×10^{5}	5.5×10^{5}
		- Ni	2.8×10^{6}	7.7×10^{5}	2.3×10^{6}	6.6×10^{6}
		- Zn	6.8×10^{7}	2.1×10^{7}	6.0×10^{7}	1.5×10^{8}

TABLE 5.5

FLUX ESTIMATES DUE TO METEORITIC DUST

Flux of metal (kg/yr) = flux of meteoritic dust (kg/yr) * element concentration in meteorites (mg/kg) * 10^{-6} kg/mg

			MEAN	5th PERCENTILE	50th PERCENTILE	95th PERCENTILE
GLOBAL	Flux of Metal (kg/yr)	- Cd	1.8×10^{-1}	4.2×10^{-2}	1.5×10^{-1}	4.2×10^{-1}
		- Cu	2.7×10^{1}	9.2×10^{0}	2.4×10^{1}	5.5×10^{1}
		- Pb	2.2×10^{-1}	4.9×10^{-2}	1.7×10^{-1}	5.4×10^{-1}
		- Hg	7.2×10^{0}	1.7×10^{0}	6.2×10^{0}	1.6×10^{1}
		- Ni	2.2×10^{3}	7.8×10^{2}	2.0×10^{3}	4.2×10^{3}
		- Zn	6.2×10^{1}	1.5×10^{1}	5.3×10^{1}	1.4×10^{2}

TABLE 5.6

MERCURY VAPOUR FLUX ESTIMATES DUE TO SOIL EVASION

Flux of metal (kg/yr) = 10^{[0.868±0.14] * log [mercury concentration in soil (Fg/kg)] - [1.1326±0.47]} * 10^6 m^2/km^2 ÷ 10^{12} ng/kg * 24 h/d * 365 d/y * area considered (km^2)

			MEAN	5th PERCENTILE	50th PERCENTILE	95th PERCENTILE
Canada	Flux of Metal (kg/yr)	- Hg	4.8×10^5	2.8×10^4	2.2×10^5	1.7×10^6
North America	Flux of Metal (kg/yr)	- Hg	4.6×10^6	7.6×10^4	6.7×10^5	5.8×10^6
Global	Flux of Metal (kg/yr)	- Hg	1.9×10^7	7.7×10^5	7.3×10^6	7.0×10^7

TABLE 5.7

MERCURY VAPOUR FLUX ESTIMATES DUE TO FRESHWATER EVASION

Flux of metal (kg/yr) = flux of metal from freshwater surfaces (kg/km²/yr) * freshwater surface area considered (km²)

			MEAN	5th PERCENTILE	50th PERCENTILE	95th PERCENTILE
Canada	Flux of Metal (kg/yr)	- Hg	8.9×10^3	2.8×10^3	8.5×10^3	1.6×10^4
North America	Flux of Metal (kg/yr)	- Hg	1.38×10^4	4.1×10^3	1.3×10^4	2.4×10^4
Global	Flux of Metal (kg/yr)	- Hg	1.3×10^5	2.8×10^4	1.2×10^5	2.8×10^5

TABLE 5.8

MERCURY VAPOUR FLUX ESTIMATES DUE TO MARINE EVASION

Global: Flux of metal (kg/yr) is taken directly from the literature
Canada/North America: Flux of metal (kg/yr) = [Global flux of metal (kg/yr) - Equatorial Pacific flux of metal (kg/yr)] * Ocean area considered (km^2) ÷ [Global ocean area (km^2) - Equatorial Pacific ocean area (km^2)]

			MEAN	5^{th} PERCENTILE	50^{th} PERCENTILE	95^{th} PERCENTILE
Canada	Flux of Metal (kg/yr)	- Hg	2.7×10^4	5.2×10^3	2.6×10^4	5.1×10^4
North America	Flux of Metal (kg/yr)	- Hg	8.9×10^4	1.7×10^4	8.6×10^4	1.7×10^5
Global	Flux of Metal (kg/yr)	- Hg	3.1×10^6	6.0×10^5	3.0×10^6	5.6×10^6

TABLE 5.9

MERCURY VAPOUR FLUX ESTIMATES DUE TO EVASION FROM PLANTS

Flux of metal (kg/yr) = -11.2 + 5.59 * ln[metal concentration in soil (Fg/kg)] * {forest area considered + [grassland/bushland area considered (km^2) ÷ forest canopy area : ground area ratio]}

			MEAN	5th PERCENTILE	50th PERCENTILE	95th PERCENTILE
Canada	Flux of Metal (kg/yr)	- Hg	5.5×10^5	4.1×10^5	5.6×10^5	6.6×10^5
North America	Flux of Metal (kg/yr)	- Hg	1.2×10^6	8.7×10^5	1.3×10^6	1.5×10^6
Global	Flux of Metal (kg/yr)	- Hg	3.9×10^6	2.7×10^6	4.0×10^6	4.9×10^6

TABLE 5.10

TOTAL METAL FLUX ESTIMATES (ALL SOURCES COMBINED)

Note that statistics for total fluxes can not be derived by simple addition of source-specific figures presented in Table 4.1 through Table 4.9

RESULTS

			MEAN	5^{th} PERCENTILE	50^{th} PERCENTILE	95^{th} PERCENTILE	Median estimates from Nriagu (1989)
CANADA	Flux of Metal (kg/yr)	- Cd	5.3×10^4	1.9×10^4	4.8×10^4	1.1×10^5	
		- Cu	2.6×10^6	3.5×10^5	1.9×10^6	7.6×10^6	
		- Pb	9.7×10^5	2.9×10^5	8.2×10^5	2.2×10^6	
		- Hg	1.1×10^6	5.4×10^5	8.2×10^5	2.3×10^6	
		- Ni	1.0×10^6	1.7×10^5	8.0×10^5	2.7×10^6	
		- Zn	4.6×10^6	1.2×10^6	3.9×10^6	1.0×10^7	
NORTH AMERICA	Flux of Metal (kg/yr)	- Cd	7.1×10^5	2.4×10^5	6.3×10^5	1.5×10^6	
		- Cu	5.0×10^7	7.4×10^6	3.8×10^7	1.4×10^8	
		- Pb	4.5×10^7	6.6×10^6	3.4×10^7	1.3×10^8	
		- Hg	5.6×10^6	2.2×10^6	4.7×10^6	1.1×10^7	
		- Ni	2.5×10^7	5.2×10^6	2.5×1^7	8.0×10^7	
		- Zn	3.8×10^7	1.2×10^7	3.3×10^7	8.5×10^7	
GLOBAL	Flux of Metal (kg/yr)	- Cd	4.1×10^7	1.5×10^7	3.6×10^7	8.8×10^7	1.14×10^6
		- Cu	2.0×10^9	2.7×10^8	1.5×10^9	5.5×10^9	27.7×10^6
		- Pb	1.8×10^9	3.0×10^8	1.3×10^9	5.1×10^9	12×10^6
		- Hg	5.8×10^7	2.0×10^7	4.7×10^7	1.2×10^8	2.5×10^6
		- Ni	1.8×10^9	2.2×10^8	1.3×10^9	4.9×10^9	30×10^6
		- Zn	5.9×10^9	1.2×10^9	4.7×10^9	1.5×10^{10}	45×10^6