Chart A-10: Calculating Accumulation of Metals in Soils From a Typical Bulk Biosolids Application

Chart: CALCULATING ACCUMULATION OF METALS IN SOILS FROM A TYPICAL BULK BIOSOLIDS APPLICATION

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For this example, the highest Concord NH annual average for each trace metal during 1994-2000 was used. Using averages, rather than maximums, makes sense for this example, because, over many years of repeat applications, average concentrations of each trace metal are applied. Note that this biosolids application meets even the strict limits on annual soil additions of Canadian and Washington state fertilizer laws (which do not apply to biosolids in those jurisdictions unless they are sold with specific nutrient value claims).

DATA FROM KNOWN REQUIREMENTS AND BIOSOLIDS TESTING:

biosolids source:	Concord WWTF
crop:	feed corn
nitrogen (N) needed by crop (lb./acre):	150
residual N in soil (lb/acre):	30
additional N needed (lb/acre):	120
biosolids plant-available N (PAN), 1st yr. (lb./dry ton)*:	38.26
application rate (dry tons/acre):	**3.1**

trace elements measured in biosolids (mg/kg):

Arsenic (As):	7.0
Cadmium (Cd):	4.0
Chromium (Cr):	164
Copper Cu);	256
Lead (Pb):	191
Mercury (Hg):	2.4
Molybdenum (Mo):	8.5
Nickel (Ni):	36
Selenium (Se):	17
Zinc (Zn):	491

* To calculate plant available N, enter N test data here:

TKN (mg/kg)	48600
NH4 (mg/kg)	4400
NO3 (mg/kg)	2100
Organic N (mg/kg)	42100
TKN (lb/dry ton)	97.2
NH4 (lb/dry ton)	8.8
NO3 (lb/dry ton)	4.2
Organic N (lb/dry ton)	84.2
% organic N available first year	30
plant availabe N (PAN), first year	38.26

	Column A Total trace element applied with biosolids (application rate x element level x 2000 lbs. / 1000000) (pounds/acre - usually applied once/year)	*Column B* Average NH agricultural soils or Northeast forage soils* from Holmgren et. al. (pounds/acre)		Total soil level of trace element after application Col. A + Col. B (pounds/acre)	WA & Canada Fertilizer Annual Addition to Soil Limit (lbs./acre/yr.)	USEPA "503" cumulative metal loading limits (pounds/acre)	1997 CWMI "Case for Caution" soil standards (pounds/acre)	**Years of biosolids application at the same annual rate to reach USEPA cumulative limit (years)**	Years of biosolids application at the same annual rate to reach CWMI cumulative limit (years)
As	0.04	12.0	*	12.04	0.297	37	1 to 10	**567**	*avg. soil over limit*
Cd	0.03	0.35		0.38	0.079	35	2	**1377**	66
Cr	1.03	200	*	201.03	N/A	N/A	N/A	**N/A**	N/A
Cu	1.61	68.0	*	69.61	N/A	1338	40 to 100	**791**	20
Pb	1.20	16.0		17.20	1.981	268	300	**210**	237
Hg	0.02	0.06		0.08	0.019	15	1	**976**	61
Mo	0.05	3.2	*	3.25	0.079	16	4	**241**	15
Ni	0.23	56.2		56.43	0.713	375	25 to 50	**1412**	*avg. soil over limit*
Se	0.11	0.4	*	0.51	0.055	32	5	**296**	43
Zn	3.08	141.6		144.68	7.329	2498	200	**765**	19

Chart A-11: Calculating Accumulation of Metals in Soils From a Typical Bulk Biosolids Application

Chart: CALCULATING ACCUMULATION OF METALS IN SOILS FROM A TYPICAL BULK BIOSOLIDS APPLICATION

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For this example, the Vermont 1999 average for each trace metal was used. Using averages, rather than maximums, makes sense for this example, because, over many years of repeat applications, average concentrations of each trace metal are applied. Vermont averages were chosen because they are the highest reported (see Chart 3.3). Note that this biosolids application meets even the strict limits on annual soil additions of Canadian and Washington state fertilizer laws (which do not apply to biosolids in those jurisdictions unless they are sold with specific nutrient value claims).

DATA FROM KNOWN REQUIREMENTS AND BIOSOLIDS TESTING:

biosolids source:	***assume the***
crop:	***same***
nitrogen (N) needed by crop (lb./acre):	***application***
residual N in soil (lb/acre):	***rate as***
additional N needed (lb/acre):	***previous***
biosolids plant-available N (PAN), 1st yr. (lb./dry ton)*:	***example***
application rate (dry tons/acre):	**3.1**

trace elements measured in biosolids (mg/kg):

Arsenic (As):	9.0
Cadmium (Cd):	3.0
Chromium (Cr):	31
Copper Cu);	490
Lead (Pb):	72
Mercury (Hg):	2.0
Molybdenum (Mo):	9.0
Nickel (Ni):	22
Selenium (Se):	6
Zinc (Zn):	649

* To calculate plant available N, enter N test data here:

TKN (mg/kg)	48600
NH4 (mg/kg)	4400
NO3 (mg/kg)	2100
Organic N (mg/kg)	42100
TKN (lb/dry ton)	97.2
NH4 (lb/dry ton)	8.8
NO3 (lb/dry ton)	4.2
Organic N (lb/dry ton)	84.2
% organic N available first year	30
plant availabe N (PAN), first year	38.26

When applied at a typical annual agronomic rate (3.1 dry tons/acre), the average 1999 Vermont biosolids could be applied for hundreds of years before the metals levels in soils reach EPA maximums.

	Column A Total trace element applied with biosolids (application rate x element level x 2000 lbs. / 1000000) (pounds/acre)	***Column B*** Average NH agricultural soils or Northeast forage soils* from Holmgren et. al. (pounds/acre)		Total soil level of trace element after application Col. A + Col. B (pounds/acre)	WA & Canada Fertilizer Annual Addition to Soil Limit (lbs./acre/yr.)	USEPA "503" cumulative metal loading limits (pounds/acre)	1997 CWMI "Case for Caution" soil standards (pounds/acre)	**Years of biosolids application at the same annual rate to reach USEPA cumulative limit (years)**	Years of biosolids application at the same annual rate to reach CWMI cumulative limit (years)
As	0.06	12.0	*	12.06	0.297	37	1 to 10	**448**	*avg. soil over limit*
Cd	0.02	0.35		0.37	0.079	35	2	**1863**	89
Cr	0.19	200	*	200.19	N/A	N/A	N/A	**N/A**	N/A
Cu	3.04	68.0	*	71.04	N/A	1338	40 to 100	**418**	11
Pb	0.45	16.0		16.45	1.981	268	300	**565**	636
Hg	0.01	0.06		0.07	0.019	15	1	**1205**	76
Mo	0.06	3.2	*	3.26	0.079	16	4	**229**	14
Ni	0.14	56.2		56.34	0.713	375	25 to 50	**2337**	*avg. soil over limit*
Se	0.04	0.4	*	0.44	0.055	32	5	**849**	124
Zn	4.02	141.6		145.62	7.329	2498	200	**586**	15

Chart A-12: New England Biosolids - Use and Disposal Methods (2000 - *updated**)

(This data is depicted in Chart 2.4.)

		Beneficial Use			Disposal			
Location	Units	Land App.	Compost	Heat Dried	Landfill	Incin.	Other	Total
Maine	dry tons	10,431	15,651		7,769		126	33,977
	% of Total	30.7%	46.1%		22.9%		0.4%	100.0%
Vermont	dry tons	2,086	3,957		1,766	384		8,193
	% of Total	25.5%	48.3%		21.6%	4.7%		100.0%
New Hampshire	dry tons	1,980	3,600		8,460	3,960		18,000
	% of Total	11.0%	20.0%		47.0%	22.0%		100.0%
Massachusetts	dry tons	2,690	18,830	32,280	53,800	145,260	13,450	266,310
	% of Total	1.0%	7.1%	12.1%	20.2%	54.5%	5.1%	100.0%
Rhode Island	dry tons		2,174		1,053	24,795		28,022
	% of Total		7.8%		3.8%	88.5%		100.0%
Connecticut	dry tons		2,385		3,180	73,935		79,500
	% of Total		3.0%		4.0%	93.0%		100.0%
New England	dry tons	17,187	46,597	32,280	76,028	248,334	13,576	434,002
	% of Total	4.0%	10.7%	7.4%	17.5%	57.2%	3.1%	100.0%

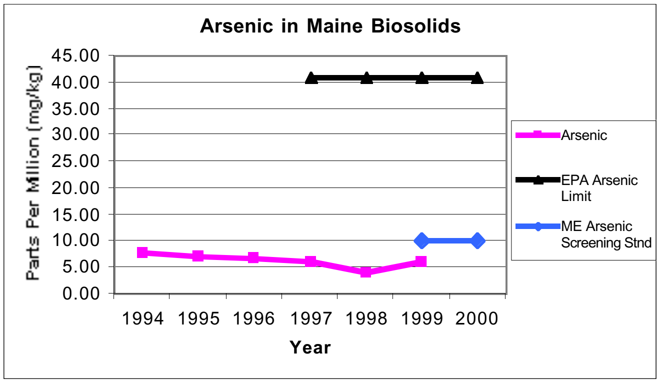
Regional Totals

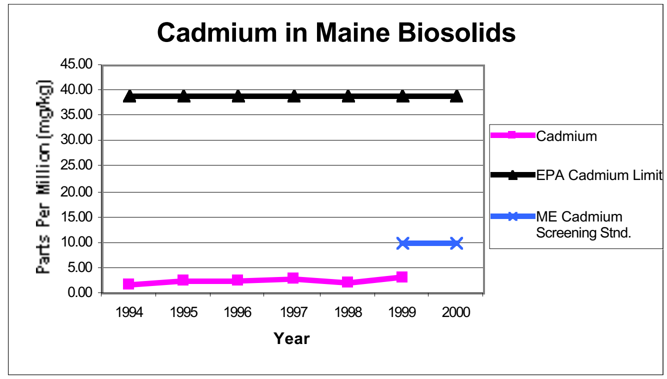
			Land App	Compost	Heat Dried	general use- Class A
Total Beneficial Use in New England	dry tons	96,064	17,187	46,597	32,280	78,877
	% of Recycled	22.1%	17.9%	48.5%	33.6%	82.1%
			landfill	**incin**	**other**	
Total Disposal in New England	dry tons	337,938	76,028	248,334	13,576	
	% of Disposed	77.9%	22.5%	73.5%	4.0%	

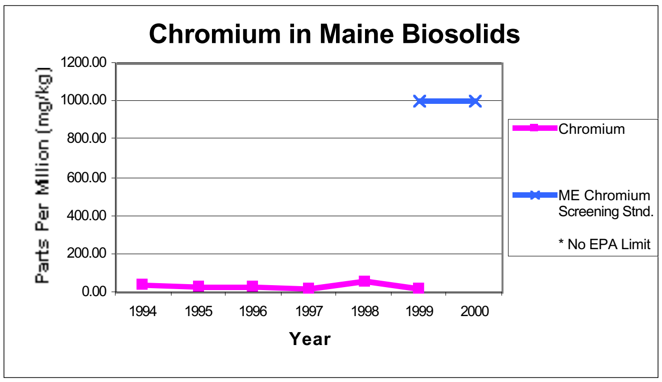
*NOTE: This table includes updated Maine numbers received at the time of publication that are not included in Chart 2.4--the difference is not great, but is significant: Maine's 2000 recycling rate was actually 77% and the total sewage sludge produced and recycled are slightly higher than reported in Chapter 2 of this report.

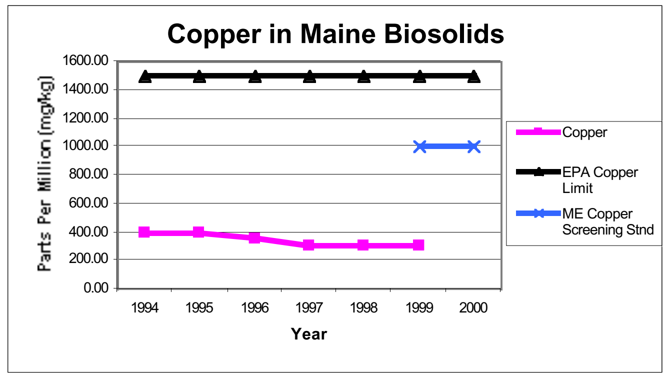
Averages by State of Trace Metals Levels Over Time: MAINE

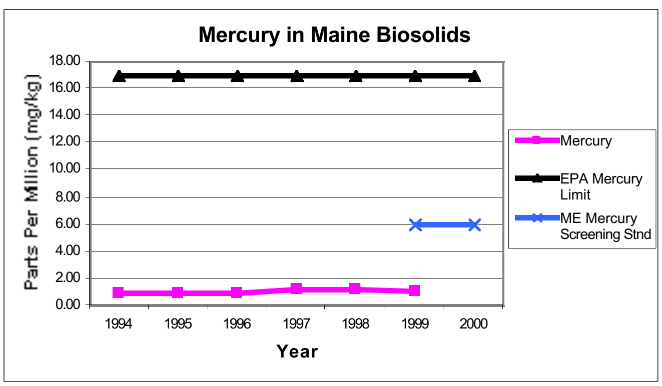
(Maine's lowest "screening" standards, Chapter 419: Table 419.3, col. A, are used for comparison.)

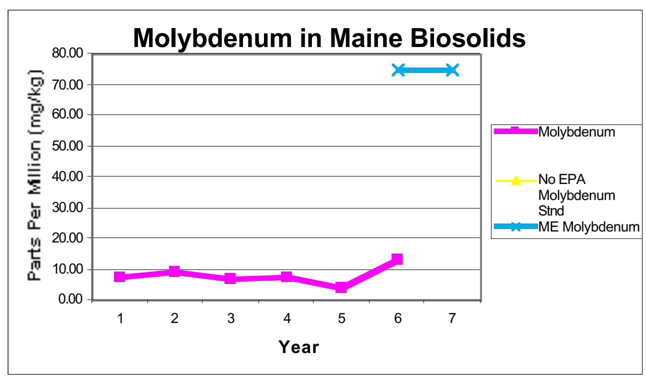


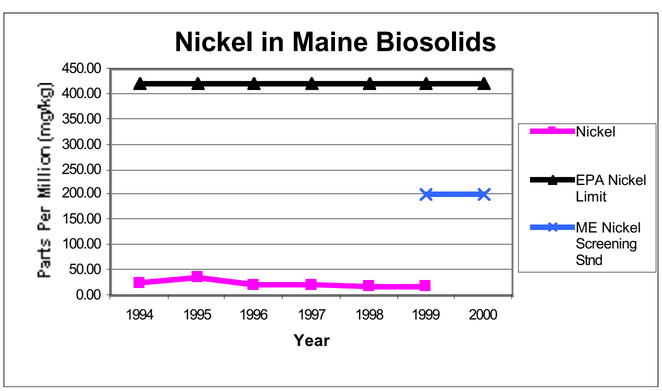


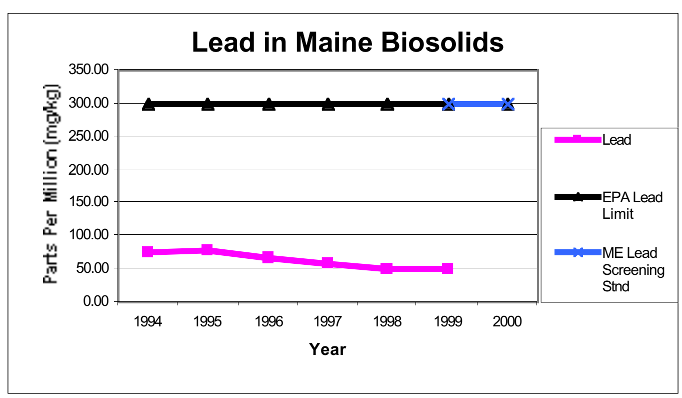


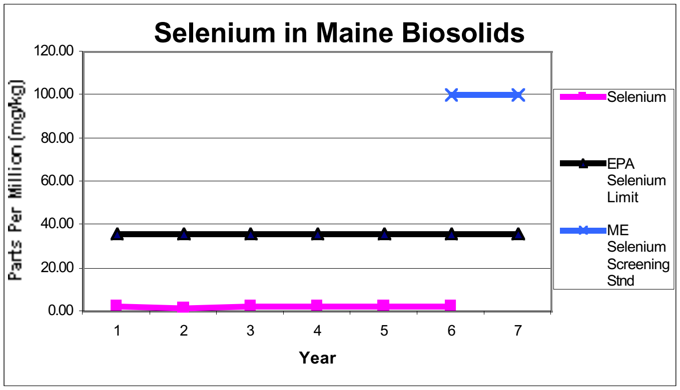


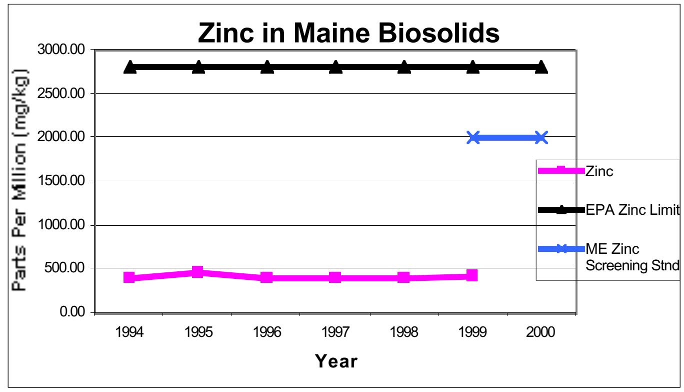






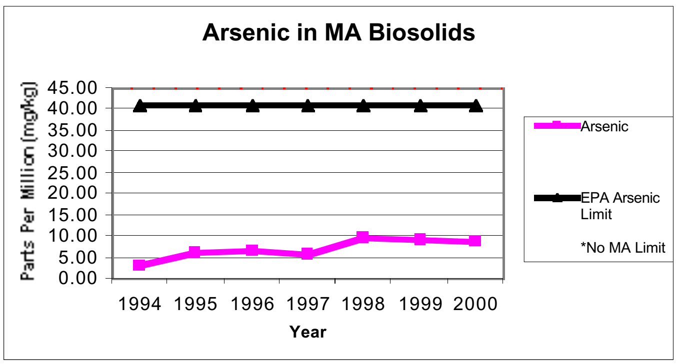


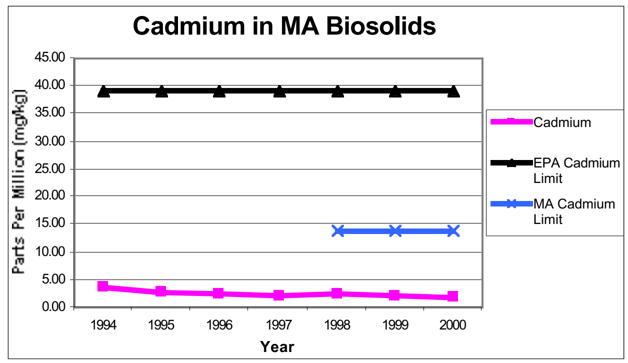


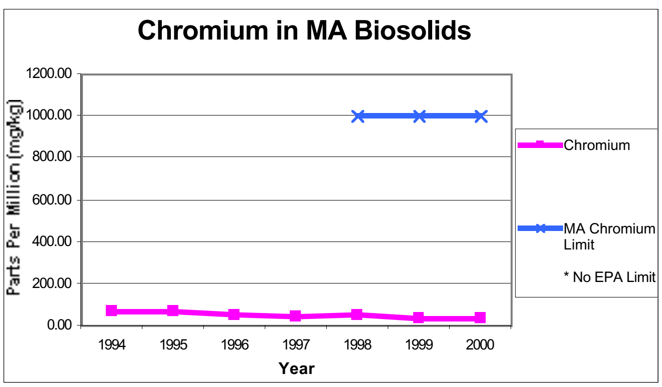


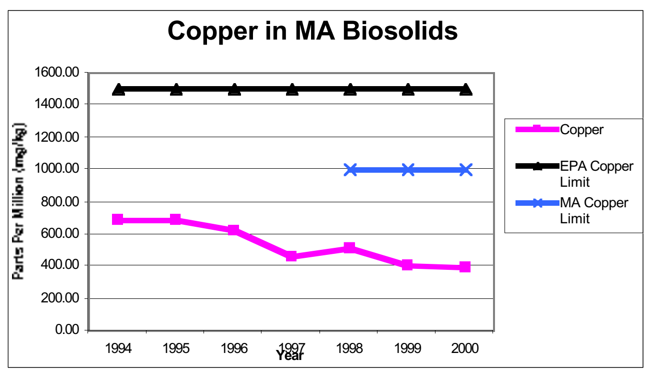
Averages by State of Trace Metals Levels Over Time: MASSACHUSETTS

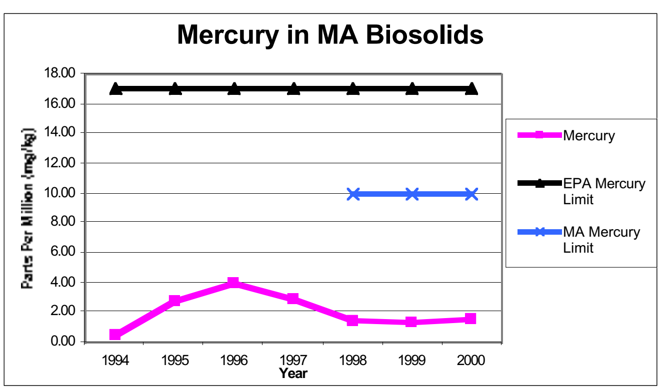
(MA lowest "Type 1 Sludge" standards, regulations Table 32.12(2)(a) are used for comparison.)

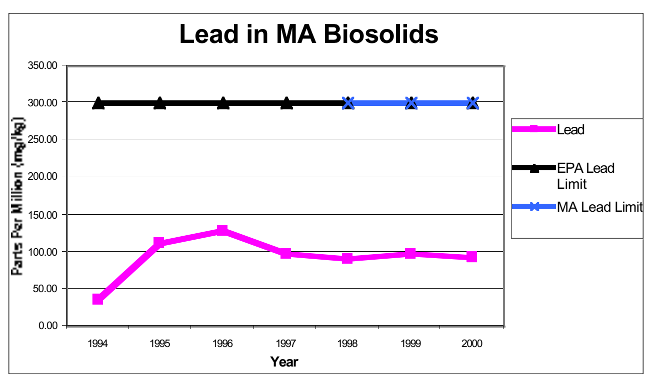


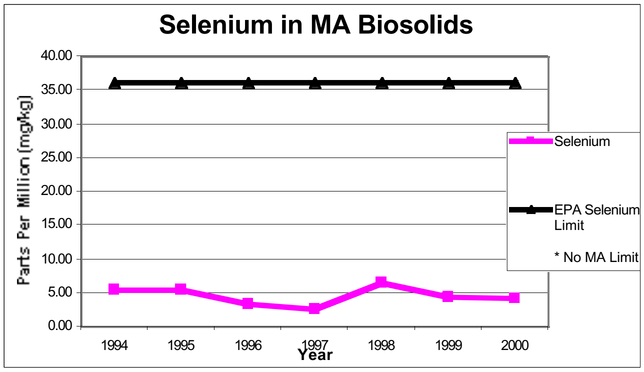


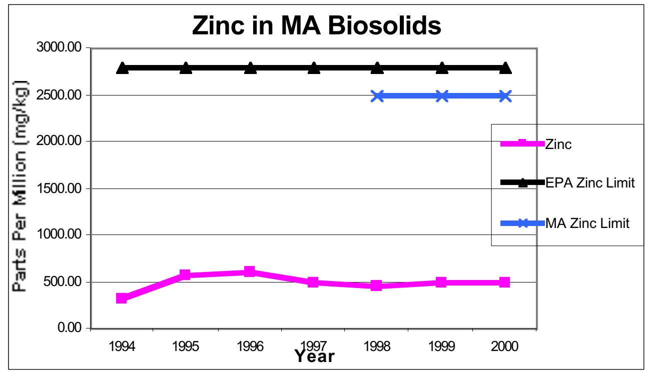






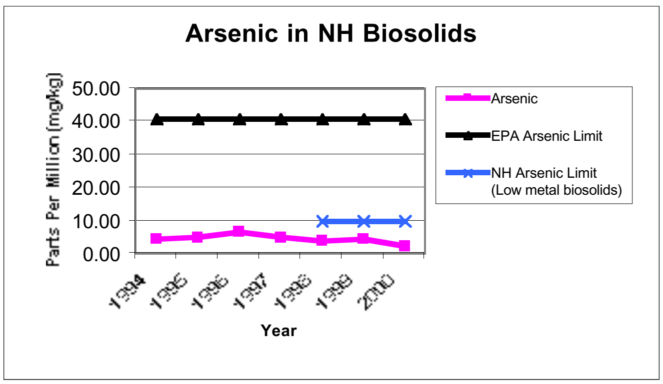


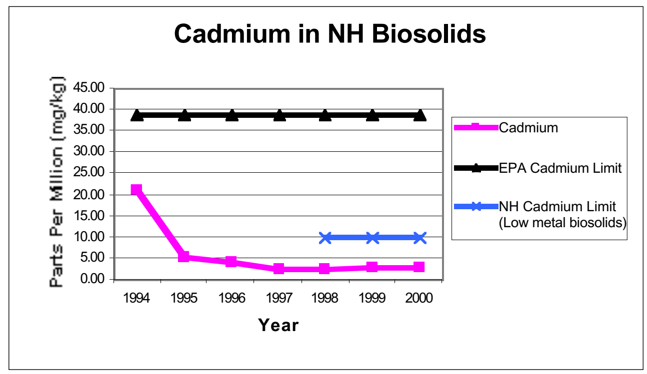


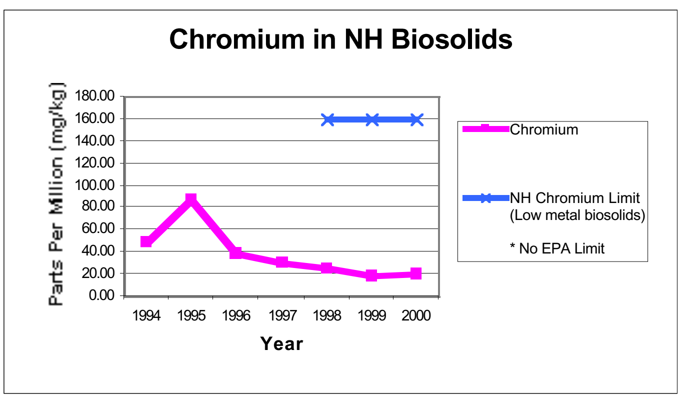


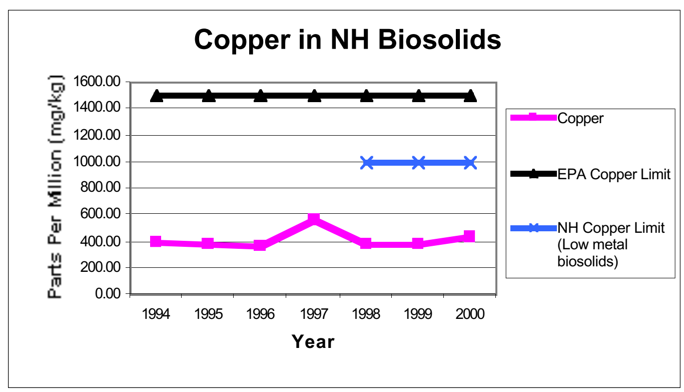
Averages by State of Trace Metals Levels Over Time: NEW HAMPSHIRE

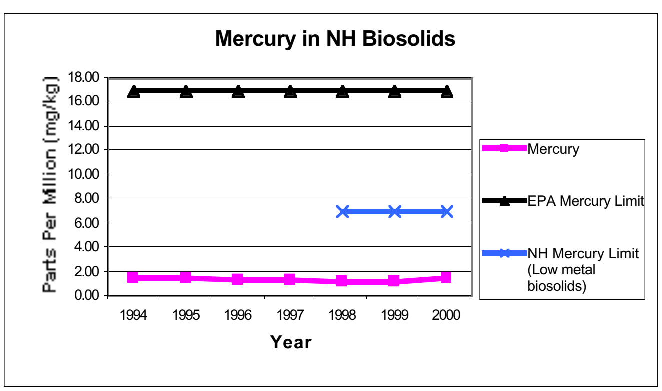
(NH "low metals biosolids" standards, regulations Env-Ws 807.03(h), are used for comparison.)

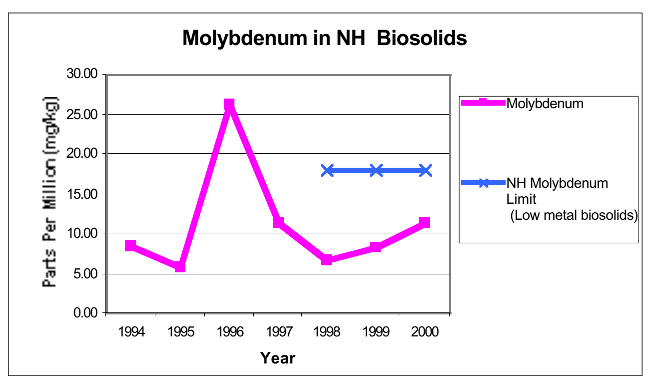


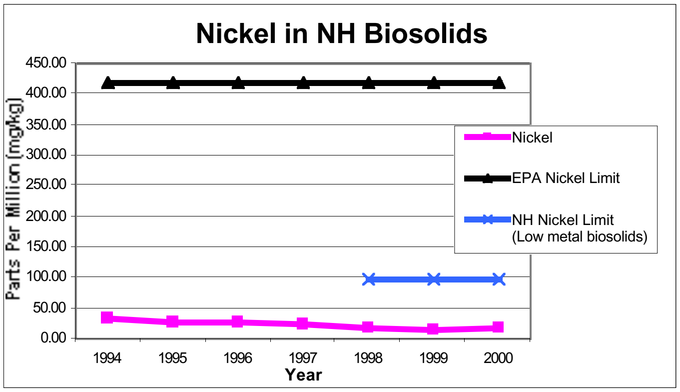


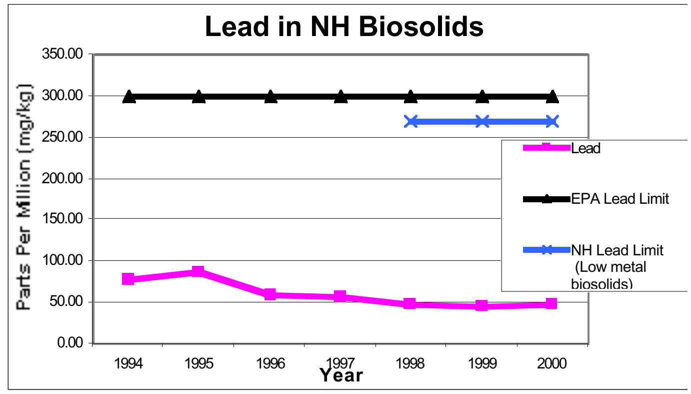


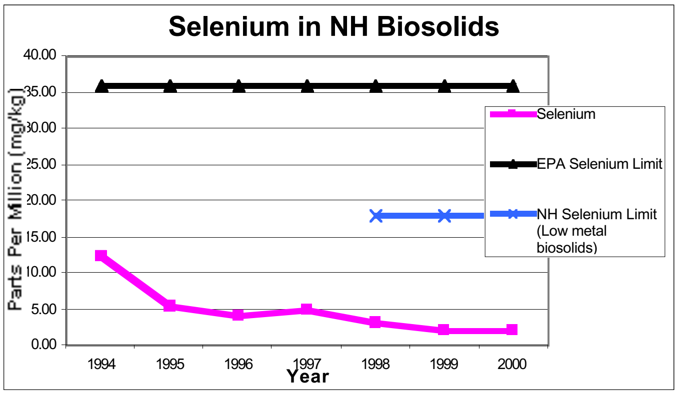


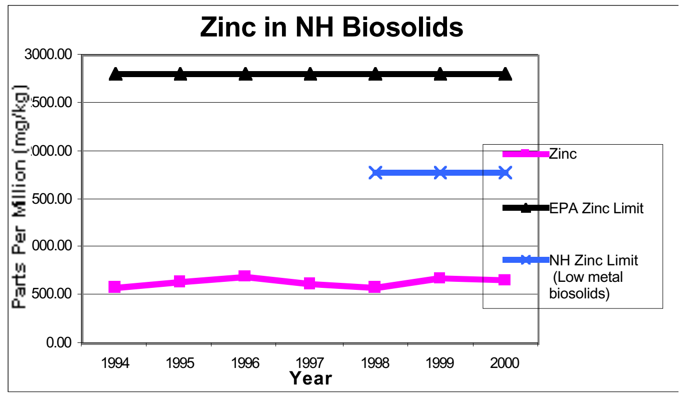




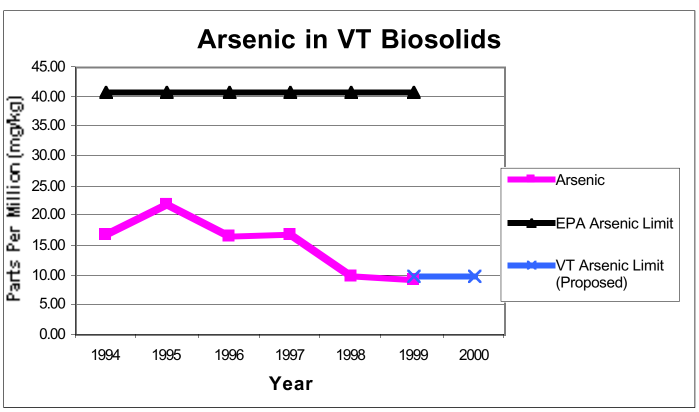


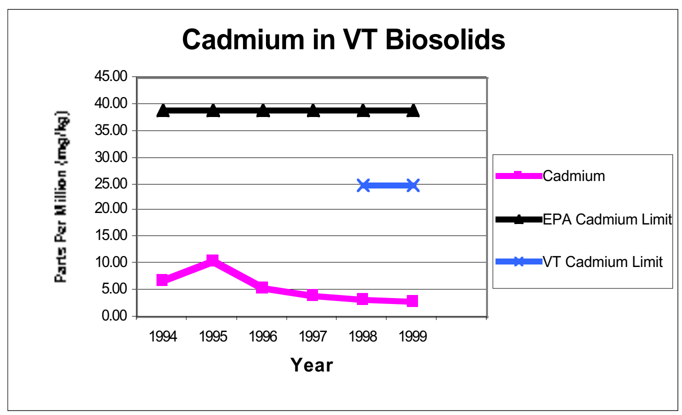


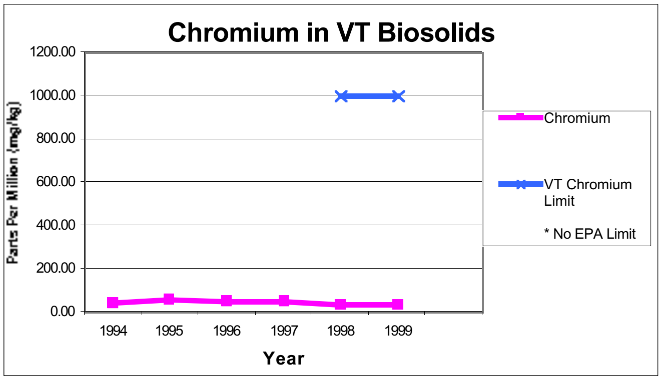


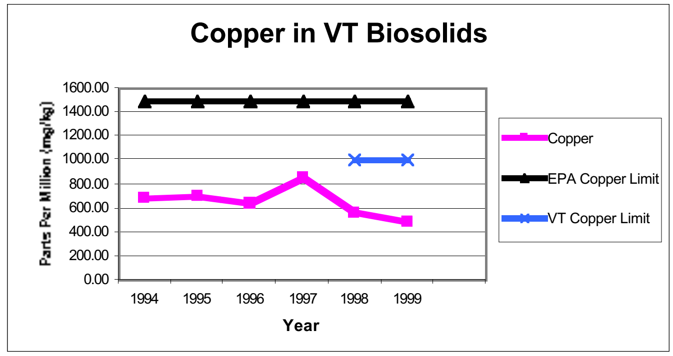


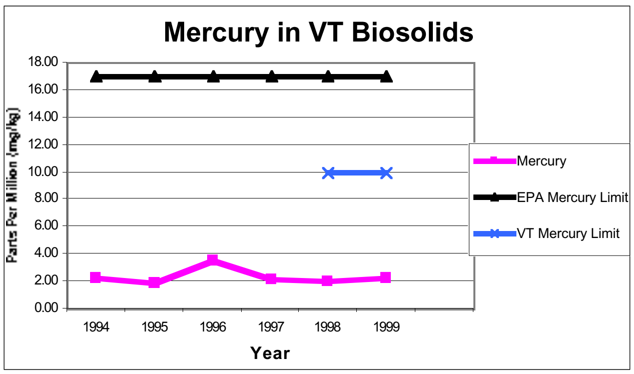
Averages by State of Trace Metals Levels Over Time: VERMONT
(VT standards, solid waste regulations subchapter 7, 6-702()(10)(B), are used for comparison.)

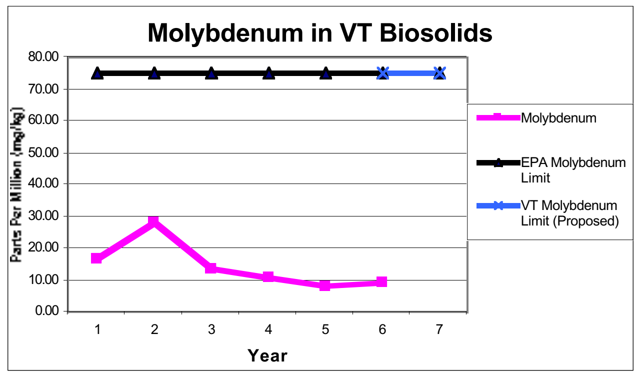


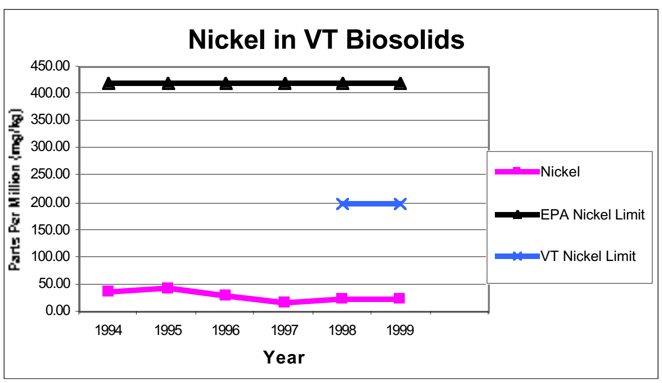



Chromium in VT Biosolids
Parts Per Million (mg/kg)
1200.00 1000.00 800.00 600.00 400.00 200.00 0.00
1994 1995 1996 1997 1998 1999
Year
Chromium
VT Chromium Limit
* No EPA Limit


Copper in VT Biosolids
Parts Per Million (mg/kg)
1600.00 1400.00 1200.00 1000.00 800.00 600.00 400.00 200.00 0.00
1994 1995 1996 1997 1998 1999
Year
Copper
EPA Copper Limit
VT Copper Limit


Mercury in VT Biosolids
Parts Per Million (mg/kg)
18.00 16.00 14.00 12.00 10.00 8.00 6.00 4.00 2.00 0.00
1994 1995 1996 1997 1998 1999
Year
Mercury
EPA Mercury Limit
VT Mercury Limit


Molybdenum in VT Biosolids
Parts Per Million (mg/kg)
80.00 70.00 60.00 50.00 40.00 30.00 20.00 10.00 0.00
1 2 3 4 5 6 7
Year
Molybdenum
EPA Molybdenum Limit
VT Molybdenum Limit (Proposed)


Nickel in VT Biosolids
Parts Per Million (mg/kg)
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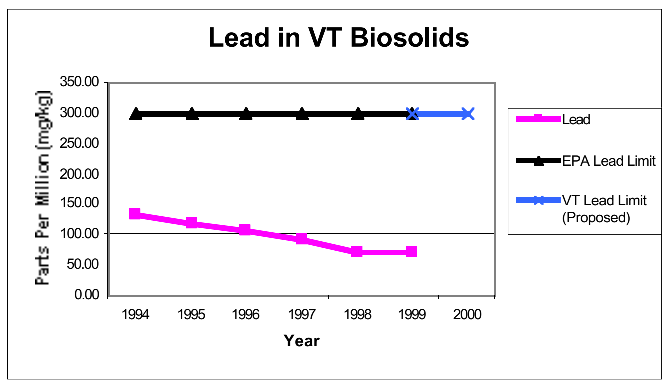
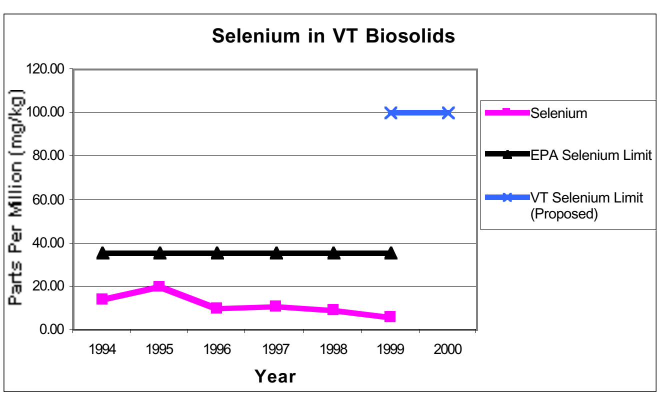
1994 1995 1996 1997 1998 1999
Year
Nickel
EPA Nickel Limit
VT Nickel Limit


Lead in VT Biosolids
Parts Per Million (mg/kg)
350.00 300.00 250.00 200.00 150.00 100.00 50.00 0.00
1994 1995 1996 1997 1998 1999 2000
Year
Lead
EPA Lead Limit
VT Lead Limit (Proposed)


Selenium in VT Biosolids
Parts Per Million (mg/kg)
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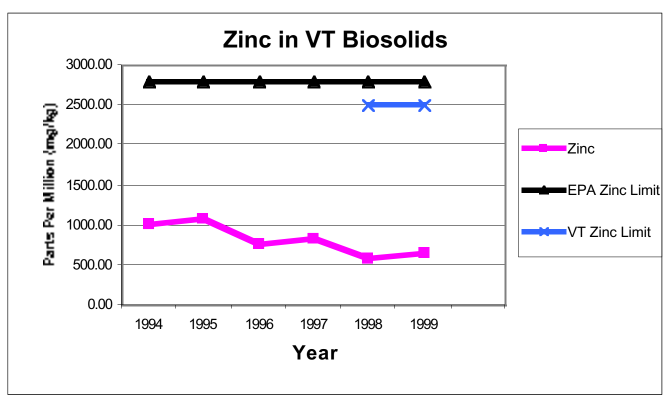
1994 1995 1996 1997 1998 1999 2000
Year
Selenium
EPA Selenium Limit
VT Selenium Limit (Proposed)


Zinc in VT Biosolids
Parts Per Million (mg/kg)
3000.00 2500.00 2000.00 1500.00 1000.00 500.00 0.00
1994 1995 1996 1997 1998 1999
Year
Zinc
EPA Zinc Limit
VT Zinc Limit