Using HAP Emissions Data to Evaluate Maximum Achievable Control Technology Standards

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Acknowledgments

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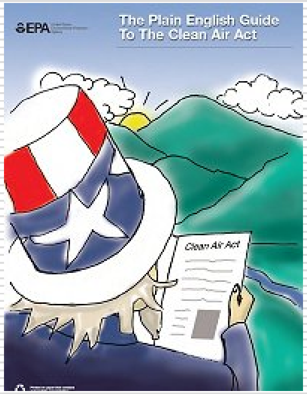
Overview of Presentation

- Introduction
- HAPs and Risk
- Applicable MACTs
- Toxicity-Weighted Emissions Approach
- Evaluation of Selected MACT Standards
- Wrap-Up

Introduction

- Acute and chronic exposure to specific hazardous air pollutants (HAPs) can lead to cancer and/or noncancer effects.



- The 1990 CAAA:
  - Identified 180+ HAPs
  - Listed 170+ source categories for development of Maximum Achievable Control Technology (MACT) Standards to reduce HAP emissions.

Introduction

- Large reductions in HAP emissions may not necessarily translate into significant reductions in health risk.

- It is difficult to assess toxicity by comparing mass emissions…a little dioxin (pounds) can hurt you…

- Thus, it is important to target the HAPs which cause the greatest health risk.

HAPs and Risk

- Individual HAP toxicity varies by pollutant. For example:
  - 2002 National Emissions Inventory (NEI): acetaldehyde mass emissions are more than double than acrolein emissions on a national basis
  - According to the Integrated Risk Information System (IRIS), acrolein is 450 times more toxic in terms of respiratory noncancer risk than acetaldehyde.

HAPs and Risk

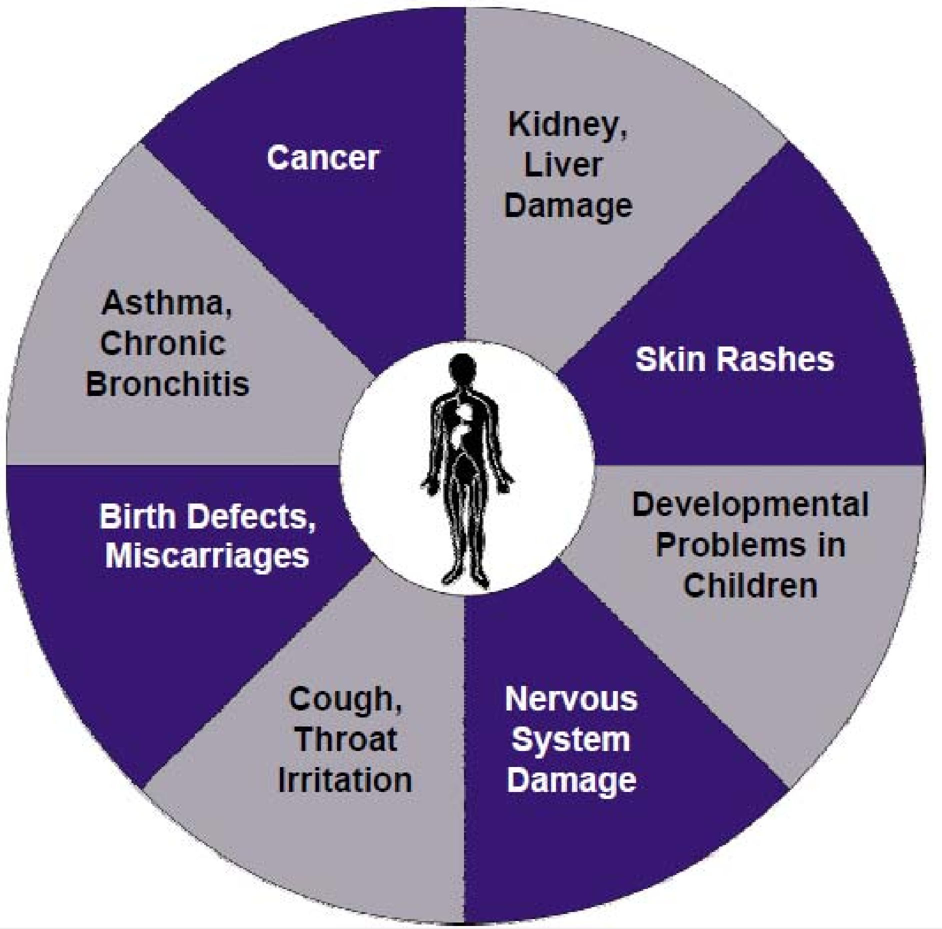
- <u>Theoretical Cancer Risk</u>: likelihood of developing cancer as a result of exposure over a 70-year period
  - Presented as the “# people/million” or “in-a-million”
  - Pollutant cancer risk can be summed for overall cancer risk.

HAPs and Risk

- Theoretical Noncancer Risk: likelihood of developing a noncancer health effect (liver, respiratory, neurological, etc) of exposure over a 70-year period.
  - Presented as the Noncancer Hazard Quotient (HQ).
  - An HQ>1 indicates that developing a noncancerous health effect is possible from that pollutant.
  - Pollutant noncancer HQs can be summed only by target area to create a Hazard Index (HI).

HAPs and Risk

Human Effects



HAPs and Risk

- EPA uses the National-scale Air Toxics Assessment (NATA) to evaluate risk.

- Starting point is the NEI, but also incorporates:
  - ambient monitoring data
  - geographic information
  - chemical/physical transformation, and
  - population exposure metrics

………………to model ambient concentrations.

HAPs and Risk

- The modeled concentrations are then applied to cancer unit risk estimate (URE) and noncancer reference concentration (RfC) factors to yield cancer and noncancer risk.

- NATA99: Released Feb. 2006

  NATA02: Released April 2009 (planned)

  NATA05: Initial runs – Summer 2009 (planned)

MACT Standards

- MACT Standards are typically implemented three years after promulgation.
- There were 9 MACTs which were implemented in 2003 and 2004:
  - Polymers and Resins III (1/20/2003)
  - Primary Aluminum Production (3/24/2003)
  - Pesticide Active Ingredient (12/23/2003)
  - Pulp and Paper Production (1/12/2004)
  - Solvent Extraction for Vegetable Oil (4/12/2004)
  - Flexible Polyurethane Foam Fabrication (4/14/2004)
  - Manufacture Of Nutritional Yeast (5/21/2004)
  - Boat Manufacturing (8/22/2004)
  - Primary Magnesium Production (10/4/2004)

Toxicity-Weighted Emissions Approach

- Methodology presented at the 2007 Emission Inventory Conference

http://www.epa.gov/ttn/chief/conference/ei16/session6/a.pope.pdf

- Similar methodology was used in mid-90s to identify the 112(k) regulatory pollutants (Top 40, Dirty 30)

- Good approach to screen, identify, compare, and prioritize pollutants of concern

Toxicity-Weighted Emissions Approach

- Step 1: Obtain the HAP emissions data. Facilities subject to MACTs of interest are identified in the 2005 NEI.
- Step 2: Apply the "Metal_CN Speciation Factor" file to extract the metal and cyanide mass for all HAPs, except for two chromium species (pollutant codes = 7440473 and 136). Non-metals multiplied by 1.

Toxicity-Weighted Emissions Approach

- Step 3: Chromium (7440473) and chromium compounds (136) need to be speciated into trivalent and hexavalent chromium species:
  - Trivalent chromium is non-toxic, hexavalent chromium is toxic.
  - Apply chromium speciation profile by industry group using MACT codes, SIC codes, and SCCs.

Chromium Speciation for Selected Industry Groups

MACT Code	MACT Source Category	% Hexavalent Chromium	% Trivalent Chromium
0201	Primary Aluminum Production	3	97
0407	Clay Products Manufacturing	43	57
0502	Petroleum Refineries	10	90
0701	Aerospace Industries	25	75
0801-3	Hazardous Waste Incineration: Cement Kilns	8	92
1607	Chromic Acid Anodizing	80	20
1610	Decorative Chromium Electroplating	95	5
1615	Hard Chromium Electroplating	98	2
1807-1	Commercial and Industrial Solid Waste Incineration	19	81
1808-1	Utility Boilers: Coal	12	88
1808-2	Utility Boilers: Natural Gas	4	96
1808-3	Utility Boilers: Oil	18	82

Toxicity-Weighted Emissions Approach

- Step 4: Calculate the tox-weighted emissions:
  - For cancer weighting, multiply the emissions from Steps 2 and 3 by the cancer URE.
  - For noncancer weighting, divide the emissions from Steps 2 and 3 by the noncancer RfC for each target organ.

Example calculations

Benzene cancer toxicity = Benzene emissions * Speciation Factor * Cancer URE

Benzene cancer toxicity = 1000 tons * 1 * 7.8e-6 μg/m^3

Benzene cancer toxicity = **0.0078**

Chrome VI noncancer toxicity = $\frac{\text{Chromium emissions * Chrome VI Speciation Factor}}{\text{Noncancer RfC}}$

Chrome VI noncancer toxicity = $\frac{\text{3.0 tons * 0.0334}}{0.0001\ m^3/\mu g}$

Chrome VI noncancer toxicity = **1002**

*** Note: calculated values are meaningless; useful for priority ranking/comparison**

Example calculations – St. Louis County, MO

Top 10 Cancer Pollutants*

Rank	Pollutant	Cancer Toxicity Weight
1	Benzene	0.00197
2	1,3-Butadiene	0.00090
3	Arsenic	0.00037
4	Hydrazine	0.00032
5	Naphthalene	0.00026
6	Acetaldehyde	0.00014
7	Nickel	0.00011
8	Tetrachloroethylene	0.00011
9	POM as 7-PAH	0.00009
10	Chromium (VI)	0.00009

Top 10 Noncancer Pollutants*

Rank	Pollutant	Noncancer Toxicity Weight
1	Acrolein	386,409.4
2	Chlorine	23,771.3
3	HCl	17,433.4
4	Formaldehyde	16,333.6
5	1,3-Butadiene	14,995.1
6	Nickel	10,815.4
7	Maleic Anhydride	9,645.6
8	Benzene	8,414.8
9	Acetaldehyde	6,987.5
10	Manganese	5,315.5

* All sectors (point, area nonpoint, onroad, and nonroad) from 2002 NEI

Study Goal

- Although NATA modeling and ambient monitoring are the best metrics for evaluating the effectiveness of MACT standards, the comparison of the toxicity-weighted emissions between the two base years can preliminarily suggest the effectiveness of the implemented MACT standards.

- Using the 2002 and 2005 NEIs, mass and toxicity-weighted emission reductions may be realized.

Results

- The facilities subject to these MACT standards were identified in the 2005 NEI.
  - 787 facilities and emissions extracted from the 2005 NEI
  - 682 facilities and emissions extracted from the 2002 NEI

- This study only examined emissions data for facilities and pollutants that were in both the 2002 and 2005 NEIs, and not total emissions from each of those facilities.

Cancer-causing Pollutant Results

MACT Standard	# Sites	Mass Emissions (tpy)		Cancer Toxicity-Weighted Emissions		% Change in Mass Emissions	% Change in Tox-Weighted Emissions
		2002	2005	2002	2005		
Polymers & Resins II	22	172.36	113.07	0.00012	0.00018	-34.4%	+58.3%
Primary Aluminum Production	99	177.04	98.95	0.01534	0.01251	-44.1%	-18.4%
Pesticide Active Ingredient	19	247.68	226.47	0.01017	0.00958	-8.6%	-5.8%
Pulp & Paper Production	140	5,480.07	5,590.55	0.16399	0.13372	+2.0%	-18.5%
Solvent Extraction for Vegetable Oil	40	14.50	166.76	0.00076	0.00174	+1,049%	+129%
Flexible Polyurethane Foam Fabrication	3	16.846	16.849	0.00007	0.00007	+0.02%	+<0.01%
Manufacture of Nutritional Yeast	2	48.79	48.79	0.00011	0.00011	--	--
Boat Manufacturing	48	3.44	4.53	0.00149	0.00253	+31.7%	+70.5%
Primary Magnesium Refining	1	0.05	0.05	0.00001	0.00001	--	--
Overall	**374**	**6,160.79**	**6,226.01**	**0.19204**	**0.16046**	**+1.7%**	**-16.5%**

Cancer screening notes

- Decreases in comparative emissions were realized for:
  - Pesticide Active Ingredient (-8.6%)
  - Polymers and Resins III (-34.4%)
  - Primary Aluminum Production (-44.1%).

- Decreases in comparative toxicity-weighted emissions were realized for:
  - Pesticide Active Ingredient (-5.8%)
  - Pulp and Paper Production (-16.5%)
  - Primary Aluminum Production (-18.4%).

Cancer screening notes

- Polymers and Resins III emissions decreased by 34%, while cancer toxicity-weighted emissions increased by over 58%;
- Pulp and Paper emissions increased by 2%, while cancer toxicity-weighted emissions decreased by over 18%;
- Overall:
  - Emissions of the cancer-causing pollutants increased by less than 2%
  - Toxicity-weighted emissions of the cancer-causing pollutants decreased by over 16%.

Cancer screening notes

- Large increase in MACT emissions for Solvent Extraction for Vegetable Oil (+1,049%); one facility, Archer Daniels Midland, increased comparative emissions from 14.5 tpy to 166.8 tpy.
  - Resulting toxicity-weighted emissions increased by 129%
  - May be the result of under-reporting in 2002.

Noncancer screening notes

- Results segregated by up to 14 target systems (e.g., respiratory, neurological, etc.)
- Detailed results in corresponding paper

Noncancer Comparison

MACT Standard	Mass Emissions…	Toxicity-Weighted Emissions…
Primary Aluminum Production	…decreased for 10 of 12 Target Systems	...decreased for 7 of 12 Target Systems
Pesticide Active Ingredient Production	…decreased for 9 of 14 Target Systems	…decreased for 6 of 14 Target Systems;
Solvent Extraction for Vegetable Oil	…increased for 10 of 12 Target Systems;	…increased for 9 of 12 Target Systems;
Boat Manufacturing	…increased for 10 of 11 Target Systems	…increased for 10 of 11 Target Systems
Flexible Polyurethane Foam Fabrication	…increased for 7 of 8 Target Systems	…increased for 7 of 8 Target Systems;
Polymers and Resins III	…decreased for 7 of 11 Target Systems	…decreased for 6 of 11 Target Systems
Pulp and Paper Production	…decreased for 8 of 14 Target Systems	…decreased for 9 of 14 Target Systems

Note: Emissions did not change for Primary Magnesium Production and Manufacture of Nutritional Yeast from 2002 to 2005

Overall Noncancer-causing Pollutant Results

Target System	# Sites	Mass Emissions (tpy)		Noncancer Toxicity-Weighted Emissions		% Change in Mass Emissions	% Change in Tox-Weighted Emissions
		2002	2005	2002	2005		
Developmental	407	47,193.7	55,581.3	429,674	436,971	+17.7%	+1.7%
Endocrine	58	85.9	67.3	309	263	-21.7%	-15.1%
Hematological	143	14.4	19.2	622	885	+33.1%	+42.3%
Immunological	301	327.3	397.3	716,413	1,768,798	+21.4%	+146.9%
Kidney	208	204.3	224.6	428,483	258,583	+9.9%	-39.7%
Liver	245	2,592.6	2,167.4	23,689	21,496	-16.4%	-9.3%
Neurological	552	18,008.4	23,104.5	2,988,154	1,725,300	+28.3%	-42.3%
Ocular	62	66.7	52.5	126	116	-21.4%	-7.6%
Reproductive	114	711.0	435.6	38,815	26,450	-38.7%	-31.9%
Respiratory	525	26,568.6	25,615.4	9,971,893	10,615,690	-3.6%	+6.5%
Skeletel	84	954.0	754.5	31,801	25,148	-20.9%	-20.9%
Spleen	10	0.4	0.5	404	502	+24.1%	+24.1%
Thyroid	18	9.8	5.2	7,859	6,329	-46.9%	-19.5%
Whole Body	76	638.1	578.2	1,524	1,341	-9.4%	-12.0%

Wrap-Up

- Toxicity-weighting data from an emissions inventory can be useful for preliminarily evaluating MACT effectiveness.
- Overall emissions of the cancer-causing pollutants for nine MACT Standards increased by less than 2%, yet there was a 16% reduction in cancer toxicity-weighted emissions.
- Overall emissions of the noncancer-causing pollutants for nine MACT Standards increased by nearly 12%, yet there was a reduction in noncancer toxicity-weighted emissions for 9 of 12 target systems.

Questions?

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