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Project Summary

Development and Selection of Ammonia Emission Factors for the 1985 NAPAP Emissions Inventory

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The report, prepared for the National Acid Precipitation Assessment Program (NAPAP), identifies the most appropriate ammonia (NH_3) emission factors available for inclusion in the 1985 NAPAP Emissions Inventory. NH_3 emission factors developed for several new NAPAP source categories were compared with factors developed for other inventories. The factors determined to be the most accurate for each category are presented. NH_3 emissions estimates, based on 1985 activity levels and the emission factors presented in the report, are summarized. The total NH_3 emissions included in the inventory are 1,685,473 tons per year (TPY). Emissions factors and estimates of NH_3 emissions are given for three categories that were not included in the inventory: human breath, cigarette smoke, and human perspiration. Emission factors and/or activity levels for these categories were not sufficiently reliable to justify their inclusion in the inventory. The issue of NH_3 emissions from wildlife excrement is of particular concern. The report and other NAPAP research suggest that the net contribution of wildlife resources to the ambient concentrations of NH_3 is zero. The additional NAPAP research suggests that any NH_3 emissions from wildlife are reabsorbed into the natural biomass, resulting in a net release to the atmosphere of zero; therefore, ammonia emission factors equal to zero are given in the report. This position conflicts with studies that recommend the application of NH_3 emission factors for wildlife, thereby suggesting that NH_3 releases from wildlife sources may be significant. Clearly further research is required to resolve this issue. The most significant NH_3 emissions sources were livestock wastes, wastewater treatment, and ammonium nitrate manufacture, accounting for more than 83% of the total 1985 emissions. Emission factors for these major NH_3 sources were assigned low confidence ratings, indicating that a more comprehensive and reliable NH_3 emissions database for several significant source categories is needed.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

A major goal of the National Acid Precipitation Assessment Program (NAPAP) is the development of a comprehensive and accurate emissions inventory for pollutants which are believed to play a major role in the chemistry of acid deposition. Ammonia (NH_3) has been identified for inclusion in this inventory.

The purpose of this study was to identify the most appropriate NH_3 emission factors available for inclusion in

the 1985 NAPAP Emissions Inventory. This involved developing NH_3 emission factors for source categories not covered under a previous NAPAP effort and comparing emission factors developed in inventories prepared for NAPAP, the Canadian Environmental Protection Service (EPS), the Electric Power Research Institute (EPRI), and the NASA Langley Research Center.

In this investigation, NH_3 emission factors were developed for range animal wastes, wildlife excrement, cigarette smoking, human breath, human perspiration, and wastewater treatment. These categories, in addition to forest fires, were previously identified as potentially large NH_3 emissions sources. Relevant data were not available for developing an NH_3 emission factor for forest fires.

Though a few of the new NH_3 emission factors developed in this study may be considered natural NH_3 sources, most natural source NH_3 emission factors were developed under a separate NAPAP effort by the National Oceanic And Atmospheric Administration (NOAA).

The newly developed NAPAP factors were rated (A:highest-E:lowest) according to several criteria including the validity of the test methods used, the age of the data, and the representativeness of the database. Appendix A discusses these criteria in detail. All of the new NAPAP factors were assigned the lowest rating of E, except for factors developed for human breath and cigarette smoking which were assigned ratings of D and C, respectively.

Activity levels representative of the 1985 base year were used to estimate total emissions by source category. For wildlife excrement, reliable population data were not available.

The comparison of NH_3 emission factors developed by NAPAP, EPS, EPRI, and NASA was based on the same criteria which were used to rate the NAPAP factors (see Appendix A of the full report). For all source categories, the original NAPAP factors were chosen as the best available for inclusion in the 1985 NAPAP Inventory. Table 1 summarizes the NH_3 emission factors selected, their ratings, 1985 activity levels, and 1985 emissions estimates.

Although NH_3 emission factors are presented in Table 1 for wildlife excrement, cigarette smoking, human breath and human perspiration, emissions for these categories were not included in the 1985 NAPAP Emissions Inventory. The decision to exclude these emissions from the inventory was justified by one or more of the following reasons:

- Conflicting research results upon which the emission factors were based contributed significant uncertainty for the application to the NAPAP program.
- Activity rate data were either unavailable or unreliable.
- Calculated emissions magnitude were too small to be of interest to the NAPAP program.

The decision to exclude NH_3 emissions from wildlife excrement was based on concerns related to both the sources of data used to develop the emission factors and the uncertainty in estimates of activity rate data. This study and subsequent NAPAP research suggest that the net contribution of NH_3 from wildlife excrement is zero. This position conflicts with other research results which have recommended the application of emission factors for NH_3 from wildlife sources, suggesting that NH_3 emissions from wildlife sources may be significant.

The emission totals by source category indicate that 48 percent of the 1985 NH_3 emissions are due to range animal wastes. The top four categories, range animal wastes, livestock waste management, ammonium nitrate production, and wastewater treatment accounted for 85 percent of the total calculated 1985 ammonia emissions. However, the emission factors for these categories received low confidence ratings. This indicates a need for more accurate and comprehensive NH_3 emissions data for many significant NH_3 source categories.

Major conclusions of this study are:

1. Comparison of NH_3 emission factors developed for NAPAP, EPS, EPRI and NASA resulted in the recommendation of a set of factors for the 1985 NAPAP Inventory. In each category the original NAPAP emission factor was found to represent the best available data.
2. Total NH_3 emissions for 1985 can be broken down as follows:
   - range animal wastes (48.0 percent)
   - livestock waste management (23.2 percent)
   - ammonium nitrate production (7.6 percent)
   - wastewater treatment (4.6 percent)
   - other categories (16.6 percent)
3. A more accurate and comprehensive NH_3 emissions database should be developed for:
   - range animal wastes
   - human breath and perspiration
   - livestock waste management
   - ammonium nitrate manufacture
   - wildlife wastes
   - mobile sources
   - wastewater treatment
   - coal and fuel oil combustion
   - forest fires
   - coke manufacture

Table 1. *Summary of Ammonia Emission Factors Chosen for the 1985 NAPAP Emissions Inventory*

Source	Emission factor (lb emitted/unit)[a]	Activity rate[b]	Units	1985 Emissions (tons/yr)[c]	Emission factor rating [d]
Livestock Wastes					
Beef cattle feedlots	*13*	*2,3x10^7*	*animals*	*151,549*	*E*
Cropland spreading					
beef cattle	*1.7*	*6.5x10^6*	*animals*	*5,541*	*E*
dairy cows	*27*	*4.5 x10^6*	*animals*	*60,736*	*E*
swine	*4.3*	*4.9x10^7*	*animals*	*105,457*	*E*
sheep	*1.9*	*1.9x10^6*	*animals*	*1,809*	*E*
laying hens	*0.34*	*2.9x10^8*	*animals*	*49,839*	*E*
broilers	*0.043*	*5.0x10^8*	*animals*	*10,781*	*E*
turkeys	*0.29*	*3.9x10^7*	*animals*	*5,579*	*E*
Combustion Sources					
Coal	*0.00056*	*8.4x10^8*	*tons coal*	*235*	*E*
Fuel oil	*0.8*	*3.4x10^7*	*10^{3}gallons fuel*	*13,563*	*E*
Natural gas					
utility boilers	*3.2*	*3.5x10^6*	*10^6 ft^3 gas*	*5,703*	*C*
industrial boilers	*3.2*	*1.1x10^7*	*10^6 ft^3 gas*	*17,788*	*C*
commercial boilers	*0.49*	*7.3x10^6*	*10^6 ft^3 gas*	*1,800*	*C*
Mobile Sources					
Gasoline					
leaded gasoline	*0.42*	*5.3x10^7*	*10^3 gallons fuel*	*11,168*	*D*
unleaded gasoline	*0.63*	*5.9x10^7*	*10^3 gallons fuel*	*18,646*	*D*
Diesel	*0.95*	*2.8x10^7*	*10^3 gallons fuel*	*13,296*	*E*
Ammonium Nitrate Manufacture					
Neutralizer					
anulator	*18[e]*	*1.9x10^6*	*tons produced*	*17,818*	*D[f]*
high density prilling	*18[e]*	*2.4x10^6*	*tons produced*	*21,820*	*D[f]*
low density prilling	*18[e]*	*9.0x10^5*	*tons produced*	*8,080*	*D[f]*
Solids formation					
evaporation/concentration					
high density	*17[e]*	*5.8x10^5*	*tons produced*	*4,905*	*D[f]*
low density	*17[e]*	*3.2x10^5*	*tons produced*	*2,726*	*D[f]*
high density prill towers	*57.2*	*2.4x10^6*	*tons produced*	*68,244*	*A*
low density prill towers	*0.26*	*6.4x10^5*	*tons produced*	*83*	*A*
rotary drum granulators	*59.4*	*1.4x10^5*	*tons produced*	*4,011*	*D[f]*
high density prill coolers	*0.04*	*7.2x10^5*	*tons produced*	*16*	*A*
low density prill coolers	*0.30*	*0*	*tons produced*	*0*	*A*
low density prill dryers	*1.6[e]*	*1.5x10^5*	*tons produced*	*116*	*D[f]*
granulator coolers	*1.19[e]*	*0*	*tons produced*	*0*	*D[f]*
Anhydrous Ammonia Fertilizer					
Application	*19*	*5.4x10^6*	*tons fertilizer*	*50,988*	*C*
Petroleum Refineries					
FCC units	*54*	*1.6x10^6*	*10^{3}barrels fresh feed*	*42,793*	*B*
TCC units	*6*	*1.7x10^4*	*10^{3}barrels fresh feed*	*52*	*B*
Reciprocating engine compressors	*0.2*	*NA[h]*	*10^3 ft^3 gas burned*	*NA*	*B*
Ammonia Synthesis					
Carbon dioxide regeneration	*2.0*	*4.9x10^6*	*tons produced*	*4,896*	*A*
Condensate stripping	*2.2*	*3.1x10^6*	*tons produced*	*3,464*	*A*
Urea Manufacture					
Solution formation/concentration	18.2	4.8x10^6	tons produced	44,122	A
Solids formation					
nonfluidized bed prilling					
agricultural grade	0.87	0	tons produced	0	A
fluidized bed prilling					
agricultural grade	2.9	5.2x10^5	tons produced	749	A
feed grade	4.1	1.0x10^4	tons produced	21	A
drum granulation	2.2	2.6x10^6	tons produced	2,897	A
rotary drum cooler	0.0051	4.1x10^5	tons produced	0.1	A

(continued)

Table 1. (Continued)

Source	Emission factor (lab emitted unit)[a]	Activity rate[b]	Units	1985 Emissions (tons/yr)[c]	Emission factor rating[d]
Coke Manufacture					
Oven charging	0.02	$3.6x10^7$	tons coal charged	358	D
Door leaks	0.06	$2.1x10^7$	tons coal charged	645	D
Coke pushing	0.1	$2.7x10^7$	tons coal charged	1,364	D
Quenching (contaminated water)	0.28	$2.7x10^7$	tons coal charged	3,525	D
Ammnium Phosphate Manufacture	0.14	$8.2x10^6$	tons P_2O_5 produced	571	A
Range Animal Excrement					
Beef cattle	44.4	$2.6x10^6$	unconfined pop	578,890	E
Dairy cattle	45.0	$4.9x10^6$	unconfined pop	109,725	E
Swine	39.0	$4.8x10^6$	unconfined pop	94,593	E
Sheep	4.5	$1.0x10^7$	unconfined pop	22,606	E
Wastewater Treatment	19.0	$8.2x10^6$	106 gallons	77,762	E
Wildlife Excrement[g]					
Big Game					
carnivores	0.0	NA	kg animal	NA	E
herbivores	0.0	NA	kg animal	NA	E
Birds	0.0	NA	kg animal	NA	E
Cigarette Smoking[i]	1.8	$7.5x10^7$	10^3 smokers	68	C
Human Breath[i]					
Smokers	9.1	$7.5x10^7$	10^3 smokers	340	D
Non-smokers	12.0	$1.5x10^8$	10^3 non-smokers	911	D
Human perspiration[i]	0.55	$2.3x10^8$	person	60,000	E

[a]All factors chosen were developed by NAPAP unless otherwise indicated.
[b]Activity rates are from the 1985 NAPAP Emission Inventory.
[c]Emissions totals do not include 44,218 tons from minor point source process emissions: area source category 99.
[d]See Appendix A of the report for explanation of ratings. A is highest; E is lowest.
[e]Emission factor is from midpoint of range reported in EPA report AP-42.
[f]Rating is lower than that reported in AP-42 because of the listing of a single factor rather than a range (as in AP-42).
[g]Emission factors as high as 1.6 lb/kg animal for carnivores, 0.14 lb/kg animal for herbivores, and 1.3 lb/kg animal for birds were developed. These emission factors were based on research results that were not representative of the wilderness environment. Other NAPAP research results based on direct NH_3 measurements in the wilderness environment support the zero emission factor assumptions presented in this table
[h]Not available.
[i]Emission factor was developed but the emissions for these categories were not included in the 1985 NAPAP Emissions Inventory due to unreliable activity rates or emission factors, or because the total emissions were insignificant.

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The complete report, entitled "Development and Selection of Ammonia Emission Factors for the 1985 NAPAP Emissions Inventory," (Order No. PB 90-235 094/AS; Cost: $17.00, subject to change) will be available only from:
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