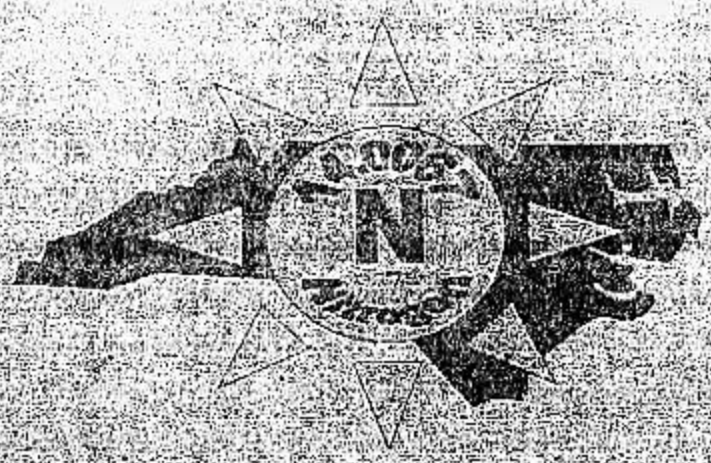

Workshop on Atmospheric Nitrogen Compounds II:

Emissions, Transport, Transformation, Deposition and Assessment

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ABSTRACTS BOOK

June 7 - 9, 1999
The Friday Center
Chapel Hill, NC

An International Workshop Sponsored By:

N.C. Department of Environmental & Natural Resources, NC DENR
N.C. Department of Health and Human Services, Office of the State Health Director, NC DHHS
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Water Resources Research Institute, WRRI
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U.S. Environmental Protection Agency, USEPA

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Session VI

Posters

Objective

Nitrogen is an essential element governing the development of living organisms, and in its various chemical forms, plays a major role in a great number of environmental issues. This workshop is scheduled as a follow up to a similar workshop held in March 1997. It is planned to be an open forum at which investigators and researchers evaluating atmospheric nitrogen emissions and fate will freely share current knowledge and ideas with other North Carolina, national and international researchers.

Workshop Chairman

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- Prof. J. Wynne, Assoc. Dean & Director, College of Agriculture and Life Sciences, NCSU (www.cals.ncsu.edu)
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- Mr. A. Klimek, P.E., Director, NC Division of Air Quality (daq.state.nc.us)
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International Perspective

NORTH CAROLINA EXPERIENCES IN ATMOSPHERIC NITROGEN STUDIES – JUNE 7, 1999

George C. Murray, Jr. ,
North Carolina Division of Air Quality

Abstract

Nitrogen compounds are needed as nutrients for plant growth and can be obtained by plants through soil, water, and/or air. Oxidized and reduced nitrogen compounds are two reactive forms that are emitted into the air from multiple types of sources. In North Carolina, nitrogen deposition from the atmosphere is believed to provide a substantial portion of the new nutrients entering eastern terrestrial and aquatic systems. While nitrogen compounds in the atmosphere, including ammonia, can have beneficial effects on various crops and other vegetation, excess nitrogen loading to ecosystems can cause a number of detrimental effects. These effects include eutrophication of rivers and coastal waters, decreases in biodiversity within ecosystems, and elevated nitrate concentration in ground water.

In 1996 the North Carolina General Assembly provided funding for research to provide a better understanding of the environmental impact of animal waste management in North Carolina, specifically, as it relates to ammonia emissions. The North Carolina Division of Air Quality, the US EPA and USDA provided additional support for research. In March 1997 a multinational State of Knowledge workshop was held. Fifteen measurement and modeling related projects have been completed or are in progress. Several of the initial projects involved measurements of emissions of ammonia compounds from swine lagoons in eastern North Carolina. Other projects examined the relationships between the changes the size of the animal industries and other potential source categories and the change in the amount of ammonium in rainfall. Dry deposition was estimated near swine facilities by measuring the amount of through fall of ammonium compounds from vegetation canopies. One project reviewed and modified the chemical and aerosol mechanisms for use in regional scale deposition modeling. The US EPA provided much of the support for the modeling activity and is continuing support for modeling.

The current understanding of ammonia emissions in North Carolina is summarized below:

- Animal production is a major source of atmospheric ammonia. Ambient ammonia levels have not exceeded the NC Air Toxics Acceptable Ambient Level at three sampling sites.
- Researchers have reported findings on ammonia emissions from waste lagoons. Nitrogen emissions from animal wastes are highly variable on a short time scale,

due to the influence of a number of factors, such as wind speed and temperature, and are affected by season.

- Lagoon emissions were measured with different technologies. The results agree within an order of magnitude. The results indicate lagoon emissions are in the same ranges as the emissions from swine farms in Europe as reported by US EPA.
- Studies concluded ammonium concentrations in rain are elevated in eastern North Carolina and ammonium concentrations and deposition correlate with changes in animal populations.
- Amounts of ammonia emissions from swine housing is likely similar to emissions from waste lagoons.

Significant progress has been made, but continued work is needed in the following areas: better understanding of emissions from other sources at swine farms and at other types of animal operations; determination of deposition rates for various surfaces in eastern North Carolina, including crops and forests; continued modeling work, including deposition and dispersion modeling; expanded monitoring; and a better understanding of the effects of nitrogen deposition.

EMISSIONS OF ATMOSPHERIC NITROGEN COMPOUNDS FROM FARM ANIMALS IN CANADA

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Abstract

Ammonia and nitrous oxide are the main nitrogen compounds emitted from agricultural operations. Agricultural activities contribute an estimated 90% of ammonia and 65% of nitrous oxide emissions from all sources in Canada. Farm animal operations contribute about 80% of the total agricultural emissions of ammonia. These emissions occur from farm structures and from land application of manure. The latter is the main source of nitrous oxide emissions from animal operations. Results from Canadian studies on ammonia and nitrous oxide emissions from animal operations, and the strategies to reduce such emissions, are summarized in the paper.

During the past decade substantial increases in animal populations, particularly hogs, has occurred in Canada. In response to a need for development of environmentally sound management practices for hog production, Agriculture and Agri-Food Canada in the federal government, in partnership with the producers and the provincial governments, initiated a Hog Environmental Management Strategy (HEMS) in 1998. The objective was to develop a national approach and an action plan to address hog environmental issues. Management of nitrogen in the overall hog production systems was identified as one of the issues to be addressed. Information of the HEMS consultation process and action plan is given in the paper.

THE DEPOSITION OF AMMONIA TO SEMI-NATURAL VEGETATION, FIELD MEASUREMENTS, MODEL SIMULATION AND NEW MEASUREMENT APPROACHES.

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Abstract

The paper covers three aspects of the exchange of ammonia between vegetation and the atmosphere, flux measurements using micrometeorological methods, simulation of the fluxes using a process based model and the development of simple, low-cost methods to obtain long term average deposition fluxes by micrometeorological methods.

Continuous measurements of the ambient concentrations and surface-atmosphere exchange of ammonia over semi-natural vegetation over a growing season are reported. The measurements show the fluxes to be controlled largely by uptake into water films on the surfaces of the vegetation, however, emission fluxes are observed on occasion, when the canopy compensation point is exceeded.

The fluxes are used to quantify annual fluxes and, when compared with the input of oxidized and reduced Nitrogen in precipitation and the dry deposition of HNO3 and NO2, to quantify the relative importance of the different Nitrogen compounds to the total input.

The field measurements are compared with modelled fluxes obtained using a dynamic, process based model which allows the effects of chemical interaction of SO2 and NH3 within water films on the vegetation on surface-atmosphere fluxes to be explored.

Lastly, recent developments of simple, low-cost flux measurement methods for ammonia, and other reactive gases are described. The methodology relies on conditional sampling of the trace gas and measurement of the eddy diffusivity to provide unbiassed ustimates of weekly or two weekly fluxes. Results of field studies during the last year to compare these methods with conventional approaches are reported.

INSTRUMENT DEVELOPMENT AND ITS APPLICATION IN STUDIES OF AMMONIA RESEARCH AND MONITORING

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Abstract

During recent years it has become obvious that ammonia is an important gas in relation to environmental themes such as acidification, eutrophication, human health and climate change (through particle formation). Therefore, there is a growing need to develop and apply instrumentation suitable for research on emission, dispersion, conversion and deposition of ammonia. ECN has developed several instruments suitable for measuring concentrations in ambient conditions even at very low levels, such as ammonia sensors suitable for monitoring and research, deposition measuring systems and aerosol samplers for on-line measurement of aerosol composition. These instruments have been tested and applied in a number of field studies. In this presentation, the methods and its specifications will be described. Furthermore, its application in field studies will be demonstrated and the results of these studies will be highlighted. These include measurements of ammonia emissions from animal housing systems and surface application of manure using the horizontal plume detection, deposition studies using the gradient system and the Relaxed Eddy Accumulation system, ambient ammonium and ammonia concentration monitoring for evaluation of abatement measures.

MODELLING THE EMISSION AND DEPOSITION OF AMMONIA ON VARIOUS SPATIAL AND TIME SCALES

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Abstract

Gaseous ammonia (NH3) and its reaction product particulate ammonium (NH4+) are important atmospheric components. They are collectively termed NHx. Deposition of these components may lead to eutrophication of terrestrial or marine ecosystems and to acidification of terrestrial ecosystems. Ammonium containing particles have influence on the earth's radiation balance and in this way they can influence the climate. Ammonium is not released as such, but is formed from ammonia that in Europe and North America mainly originates from animal husbandry and synthetic fertilizers.

An overview will be given on the methods to calculate the annually averaged ammonia emission on a national scale and the possibilities to reduce the emission. Moreover, the possibilities of modelling the emission with a high temporal resolution will be addressed as well as their consequences for atmospheric transport and deposition.

NHx is mainly dry deposited as NH3 close to sources and wet deposited further away (this wet deposition originates mainly from scavenging of NH4+). This means that the total deposition of NHx (sum of wet and dry) in or close to areas with a high emission density is dominated by dry deposition of NH3 from nearby sources and that the total deposition of NHx in more remote areas is dominated by NHx originating from scavenging of NH4+ aerosol that is being transported over long distances. As a consequence an atmospheric model for NHx should be able to describe processes on a local as well as a regional scale. Some results of atmospheric transport models on various scales will be presented. Moreover, attention will be paid to deposition in nature reserves and coastal areas.

Some examples of decision tools will be presented that can be used to evaluate the effect of emission reductions on depositions and their effects.

Session I

DETECTING AND REDUCING AMMONIA EMISSIONS FROM DAIRIES AND CATTLE FEEDLOTS: A REVIEW

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Abstract

Ammonia is one of 170 compounds detected in livestock manure odor. Ammonia is emitted from surfaces of open, unpaved cattle feedlots and dairy corrals at concentrations of 360-980 (g/m3 as compared to background levels of 1-4 (g/m3 in prior research. Ammonia volatilization losses are reportedly 50% or more of total N excreted from open lot surfaces and 23-70% following field spreading. Approaches to ammonia and odor control include improved manure collection and treatment processes, capture and treatment of odorous gases, and improved dispersion through site selection. Approaches to ammonia monitoring include acidic solution traps, chemoluminescence, and GC-MS.

RECENT ADVANCES IN THE STATE OF KNOWLEDGE REGARDING AMMONIA AND METHANE EMISSIONS FROM ANIMAL WASTE IN THE UNITED STATES AND IN EUROPE

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Pieter Meeuwissen
Animal Waste Specialist, ARCADIS
Arnhem, The Netherlands

Susan Thorneloe
Senior Engineer, EPA
Air Pollution Prevention & Control Division
Research Triangle Park, NC

Abstract

For EPA, with co-funding from NCDENR, ARCADIS Geraghty & Miller has collected recent information on ammonia and methane emissions from manure management from swine, poultry, dairy and cattle in the United States and in Europe. Manure management sources include animal houses, storage facilities, lagoons, and sprayfields. Recent emission estimates, as well as background information on emission factors and methodologies, are discussed. This study compares European emission factors with U.S. and North Carolina emission factors from field tests and identifies data gaps in animal waste ammonia and methane emission inventory development.

Ammonia and methane emission estimates for swine operations and other significant animal waste sources in North Carolina and the United States are being developed from the newly developed emission factors, recent activity data, and previous EPA information.

AMMONIA EMISSIONS FROM SWINE WASTE OPERATIONS IN NORTH CAROLINA

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George Murray and Ron McCulloch
North Carolina Department of Environment and Natural Resources
Raleigh, NC 27626 U.S.A.

Abstract

Livestock wastes account for approximately twenty-five Teragrams of nitrogen emissions yearly from a global perspective. However, there is little information available on quantification and characterization of ammonia from domestic animal waste operations in the United States. North Carolina has the second largest swine population (over 9 million animals) in the United States. Wastes from these large swine operations along with cattle and poultry operations are significant sources of ammonia (160,000 tons per year). The total amount of ammonia produced in North Carolina is close to 175,000 tons per year. Based on emission factors developed in Europe, it is estimated that swine production contributes around 47% of this total, while the total domestic animal population (swine, cattle, and poultry) may contribute about 90%. Using a dynamic chamber system interfaced to a mobile laboratory, ammonia emission source strengths were examined on several different swine waste lagoons. Source strengths of ammonia from lagoon surfaces were found to be in the range of 700-4100 micrograms per meter squared per second during the late summer months, and 400-3200 during the fall. It was also determined that ammonia-nitrogen flux was strongly correlated to the lagoon water temperature.

FIELD MEASUREMENT OF GREENHOUSE GAS EMISSION RATES AND DEVELOPMENT OF EMISSION FACTORS FOR WASTEWATER TREATMENT

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Ms. Susan Thorneloe
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National Risk Management Research Laboratory
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Research Triangle Park, NC 27711

Abstract

Greenhouse gases (GHG), including ammonia, carbon dioxide, and methane, are produced by the anaerobic decomposition of waste in landfills, septic sewage systems, lagoons, and wastewater treatment facilities. Some estimates are available for the amount of pollutants emitted from certain types of waste facilities, but there is not adequate field measurement data to validate these estimates. Therefore, field testing was performed to develop more reliable emission estimates for these sources. Field test of emissions were conducted for wastewater treatment systems that use anaerobic processes to treat large volumes of wastewater with large biological oxygen demand (BOD) loadings. Air emission and wastewater measurements were made for anaerobic lagoons at three meat processing plants and at two publicly-owned treatment works (POTWs). The overall emission rates of methane, carbon dioxide, carbon monoxide, nitrous oxide, ammonia, and chlorofluorocarbons (CFCs) were measured from each source using an open path monitoring approach. The emitted compounds were identified and quantified by Fourier Transform Infrared (FTIR) spectroscopy. Emission factors were developed for methane and ammonia as a function of the plant production rate, influent BOD loading, etc. This paper will provide an overview of this research and discuss issues associated with available data and estimates of GHG emission rates for wastewater treatment.

AMMONIA EMISSIONS FROM FIELD APPLICATIONS OF POULTRY MANURE

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Environmental Chemistry Laboratory
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Abstract

Ammonia emissions from poultry manure are a potential source of atmospheric N compounds in the Mid-Atlantic region, as well as an economic loss of plant available N to the farmer. Results from two field micrometeorology studies will be discussed which utilized the integrated horizontal flux method. These studies employed: a 40 meter diameter circle, six point conventional acid-trap samplers, and cup anemometers to quantify ammonia emissions from an application of 9 tons per hectare of poultry manure spread on the soil surface. Field experiments were conducted in the fall (late October) and spring (early March) to document ammonia losses associated with the use of poultry manure in a winter wheat cropping system. Results show losses of 15-50 percent of the poultry manure ammonium-N, which are lower losses than predicted from current agricultural nutrient management programs, and are important sources of ammonia to the atmosphere.

MEASURING CHEMICAL EMISSIONS USING ENVIRONMENTAL CAT SCANNING

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Abstract

Ammonia emissions from a waste lagoon at a swine facility were measured using a new technology that combines open-path Fourier Transform Infrared Spectroscopy (OP-FTIR) with computed tomography. This technology allows "real-time" maps of chemical concentrations and plumes in air to be reconstructed for the entire surface of the lagoon. Two rotating OP-FTIR spectrometers and 12 retroreflectors were placed on the periphery of the lagoon and infrared beams were shot across the lagoon every few seconds. Measurements were obtained within one meter of the surface of the lagoon. Real-time concentration maps were generated every two minutes during the day and during some evenings over several seasons. To calculate the ammonia emissions, neutrally buoyant sulfur hexafluoride (SF6) was used as a tracer gas and was released at known emission rates from the center of the lagoon. Both SF6 and ammonia were measured simultaneously and the concentrations and emission rates of SF6 were used to calculate the ammonia flux. The lagoon was represented as a 3x7 grid and fluxes were calculated for each grid cell. Average ammonia fluxes for data collected in November 1997 and May 1998 were – 2000 and 7000 ug/m2-min, respectively.

AMMONIA-NITROGEN EMISSIONS IN NORTH CAROLINA - COMPARISON AMONG ESTIMATES WITH DIFFERENT EMISSION FACTORS

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Abstract

Estimating ammonia emissions in North Carolina is dependent upon the availability of credible emission factors. While such factors are available for many combustion processes that result in the emission of oxidized nitrogen (NO_x-N), those for ammonia that have been compiled by the USEPA have mainly been derived from European research and a very few US studies. Using these factors, estimates of total ammonia-N emissions in North Carolina for 1996 were in excess of 130,000 tons (120,000 metric tons), about 40% of the total N emissions of almost 335,000 tons. Emissions from swine operations, estimated at more than 77,000 tons, alone account for nearly 60% of the ammonia-N total. By comparison, NO_x-N emissions from large point sources, primarily utility boilers, were nearly 92,000 tons the same year. How estimates of ammonia-N change with different estimation methods will be discussed as will the distribution of these emissions across the state.

ESTIMATING AMMONIA EMISSIONS FROM REMOTELY SENSED DATA

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[2]North Carolina State University, Department of Marine, Earth and Atmospheric Sciences, Raleigh, NC 27695, USA

Abstract

Atmospheric ammonia (NH_3) emissions from agricultural intensive livestock operations (ILO) waste treatment lagoons have been modeled by Aneja, et al, (1997, 1999) based on lagoon surface water temperature. Air and water surface temperatures from the surface treatment lagoon were then used to build a prediction equation that estimates water temperatures for given air temperatures. A time series model was then used to enhance water temperature predictions. These estimated water temperatures were then used as inputs into the ammonia emissions model, which subsequently simulated the hourly emissions of ammonia. Confidence intervals were constructed on the predictions to realize the uncertainty in the estimates. In order to compute the hourly emissions for several waste lagoons, lagoon surface areas were estimated using aerial photographs from the North Carolina State University (Libraries) SPOT GIS database. Finally, simulated seasonal emissions were computed from remotely sensed air temperatures for Eastern North Carolina and compared to ammonia emissions obtained from emissions factors.

AMMONIA-NITROGEN EMISSIONS IN NORTH CAROLINA - COMPARISON AMONG ESTIMATES WITH DIFFERENT EMISSION FACTORS

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Abstract

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NPPC's ON FARM ODOR/ENVIRONMENTAL ASSISTANCE PROGRAM

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Abstract

In June of 1996 the National Pork Producers Council decided that a major obstacle to expansion and continued profitability of the swine industry in the United States was environmental risk, both real and perceived. In order for the industry to expand and continue to prosper environmental issues needed to be address in a proactive manor. Thus, the leadership of NPPC requested Checkoff funds from the Pork Board to fund two new initiatives to address environmental issues.

The first program the On Farm Odor/Environmental Assistance Program (OFO/EAP) and the second the Odor Solutions Initiative (OSI). The OFO/EAP program is designed to address management related issues by suggesting Best Management Practices (BMP's) to deal with the environmental challenges. This program is a one on one educational opportunity for the producer during the assessment. Specially trained assessors use the opportunity to explain why things may be an environmental challenge and why a particular BMP may work. The program identifies strengths as well as challenges. This program has assessed a few hundred farms with some interesting results. One important component of this program is the database that is being created to track environmental information on the participating farms. This type of information on a large scale does not exist. The information from the database will be used to determine the things common to operations that have problems, but it will also identify the things that are common among those with no problems.

The OSI program has several components. One component is testing of measures, gathering information for a database and use of information to do some air modeling. Other components involve column testing of additives, evaluation of waste treatment and potential evaluation of variations to swine diets. This program is in its very early stages and will be reporting results some time in the next couple of years.

TRANSPORT, DEPOSITION, AND EFFECTS OF NOX EMISSIONS FROM THE U.S. ELECTRICITY SECTOR UNDERGOING RESTRUCTURING: NITROGEN DEPOSITION AND OZONE FORMATION IN THE CHESAPEAKE BAY WATERSHED REGION

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ABSTRACT

Competition in and restructuring of electricity markets could result in substantial changes in NOx emissions from power plants. This report focuses on how three potential restructuring scenarios and four EPA NOx reduction regulatory scenarios could affect NOx emissions from power plants, and resultant nitrogen loadings and ozone formation in the Chesapeake Bay watershed. The report draws on: 1) a national electricity model to characterize NOx emissions changes that could occur, and 2) unique application of EPA's CALPUFF model to evaluate deposition impacts and to begin to evaluate potential impacts to regional ozone formation.

Modeling predicts only small overall changes in total nitrogen deposition and loading rates to the Bay watershed from market restructuring. At most, the aggressive restructuring scenarios result in an up to 3.0% increase in nitrogen deposition and loading rates to the Bay watershed from the baseline restructuring scenario. The degree to which projected modest increases in nitrogen deposition affect overall water quality is expected to be small; however, even small increases in deposition may be significant in Bay tributaries with relatively tight nitrogen budgets.

We also use CALPUFF-predicted NOy as an indicator of potential ozone. Results suggest that ozone formation rates track changes in emission rates, but to a lesser degree than deposition quantities. Even under stringent NOx control scenarios, the increase in potential ozone due to restructuring is a significant fraction of the increases predicted for restructuring under the base case NOx control scenario; the increases are nonetheless modest.

A NEURAL NETWORK MODEL TO ESTIMATE AMMONIA IN THE ATMOSPHERE

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Department of Marine, Earth and Atmospheric Sciences
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Abstract

Atmospheric ammonia (NH_3) along with sulfur dioxides (SO_2), and nitrogen oxides (NO_x) has recently came to the attention of scientists primarily due to acidification and eutrophication of ecosystems. To improve air quality, it is really required to estimate the exact ammonia emissions and the wide range of studies about ammonia. Most recently, many scientists have devoted their attention to this issue. However it is difficult to estimate emissions in the atmosphere under complex conditions because ammonia emissions depend on some various influencing factors.

In this study, to estimate pollutants which are produced or reduced non-linearly under complicated chemical reactions and various meteorological conditions, we used the neural network model which favorably simulates pollutants which have non-linear relations with each other.

Input variables for the model include the target ammonia data in the atmosphere, meteorological data (relative humidity, solar radiation, air temperature, wind speed, and direction), the population of hogs, ammonia flux, and NO_y (NO_x + HNO_3 + PAN + HNO_2 + NO_3 + organic nitrates) data from hog farm lagoons at the same site and same time. Ammonia flux from hog farm lagoons is one of the most important input data to estimate the target ammonia concentration in the atmosphere at the same region. This model is also useful to evaluate the importance of different single factors in the complex system that has influence on ammonia concentration.

MULTI-POLLUTANT CONCENTRATION MAPPING AROUND A CONCENTRATED SWINE PRODUCTION FACILITY USING OPEN-PATH FTIR SPECTROSCOPY

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Abstract

Open-path Fourier Transform Infrared (OP-FTIR) spectroscopy has been used to map pollutant concentrations around a integrated industrial swine production facility in eastern North Carolina. Single measurement paths were located to separate the emissions from the farrowing and finishing operations as well as the waste water lagoon. Ammonia, methane, carbon monoxide, carbon dioxide, nitrous oxide and water vapor were found to be slightly to highly elevated above the local background. Hydrogen sulfide and mercaptans were not detected. Complex air flow in and around the production houses has not allowed calculations of emission rates using simple flow models. The concentration data suggest that the production houses can be a significant source of atmospheric ammonia and the lagoon a major source of methane. Measurements of the mechanical exhausts from the finishing barns indicate little seasonal variability of the estimated ammonia emissions.

TRENDS IN AMMONIUM CONCENTRATION IN PRECIPITATION AND LOCAL AMMONIA EMISSIONS AT A COASTAL PLAIN SITE IN NORTH CAROLINA, USA

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Abstract

The temporal characteristics of ammonium (NH_4^+) ion concentration in precipitation and local ammonia (NH_3) emissions are investigated over the period 1982-1997 at National Atmospheric Deposition Program/National Trends Network site NC35, located in Sampson County, North Carolina. Multiple regression analysis of annual volume-weighted values of NH_4^+ concentration in precipitation identifies a statistically significant ($p<0.01$) 4-year cycle and increasing trend during the period. The cycle is likely a function of mean annual surface temperature, which is shown to be a significant ($p<0.01$) predictor variable for annual NH_4^+ concentrations in precipitation. Regression analysis of monthly volume-weighted NH_4^+ concentration is used to illustrate a significant ($p<0.01$) increasing trend of approximately 0.083 mg NH_4^+ l^{-1} yr^{-1} over the period 1990-1997 (period 2) and lack of trend during the period 1982-1989 (period 1). An analysis of annual NH_3 emissions from individual sources in an intense agricultural region surrounding NC35 shows that emissions from cattle and fertilizer were not significantly different (1% level) across the two periods, while emissions from chickens were significantly ($p<0.01$) lower during period 2. Turkey and broiler emissions are believed to be constant across both periods. Swine emissions were the only source which was significantly greater ($p<0.01$) during period 2. Local ammonia emissions from swine and mean surface temperature explain approximately 95% of the variation in annual volume-weighted NH_4^+ concentrations in precipitation at NC35 during the period 1982-1997.

ATMOSPHERIC CONCENTRATIONS OF AMMONIA AND AMMONIUM AEROSOLS IN SAMPSON COUNTY, NORTH CAROLINA

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Abstract

Fate and transport of ammonia (NH_3) emitted from effluent lagoons, housing units, or land application of animal wastes (effluent or litter) is dictated in part by partitioning between ammonia and ammonium aerosols (e.g. NH_4NO_3, NH_4HSO_4, NH_4Cl) in the atmosphere. Annular denuder technology is being used to measure the atmospheric concentrations (sampling height = 2.6 m) of ammonia and ammonium aerosols in Sampson Co., NC, where there is a relatively high density of large-scale swine and poultry production facilities. From May 1, 1998 to July 1, 1998, mean day time (0700-1900 h) concentrations of ammonia expressed as nitrogen were 4.97 (+/- 1.74) $\mu g\ m^{-3}$. Mean nighttime (1900-0700 h) concentrations of ammonia were 7.52 (+/- 4/58) $\mu g\ m^{-3}$. From October 14, 1998 to December 15, 1998, mean daytime concentrations of ammonia ranged from 5.4 to 0.3 $\mu g\ m^{-3}$. Day-to-day variations in atmospheric ammonia concentrations appear to be related to changes in atmospheric temperature. Ammonium aerosols account for less than 50% of the ammonia species in the atmosphere. This research is part of a larger effort in cooperation with U.S. EPA, NOAA and UNC-IMS to calibrate and evaluate model projections of the fate and transport of ammonia in eastern North Carolina.

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Session III

SOURCE-RECEPTOR MODELING OF WET AMMONIUM DEPOSITION IN NORTH CAROLINA, USA

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Abstract

A source-receptor regression model is developed to statistically test for the influence of a particular North Carolina (NC) Coastal Plain ammonia (NH_3) source region on ammonium (NH_4^+) concentrations in precipitation at surrounding NC National Atmospheric Deposition Program/National Trends Network (NADP/NTN) sites during the period 1995-1996. The model used daily precipitation information and weekly precipitation chemistry samples collected at NADP/NTN sites in conjunction with boundary-layer air mass back trajectories calculated using version 4 of the HYSPLIT model. The source region is defined as the combined area of the six NC counties with the largest hog population densities (average = 530 hogs km^{-2}). Ammonia emissions from swine and turkey populations in this region amount for approximately 70% and 50% of total statewide emissions from each source, respectively. Results show that NH_3 emissions from this source region are found to increase NH_4^+ concentration in precipitation at NADP/NTN sites up to = 80 km away. At the Scotland County (NC36) and Wake County (NC41) sites, mean NH_4^+ concentrations in precipitation show increases of at least 44% for weeks during which 25% or more back trajectories are influenced by this source region.

ESTIMATION OF ATMOSPHERIC DEPOSITION OF AMMONIUM AND NITRATE IN NORTH CAROLINA AND COASTAL PLAIN RIVER BASINS

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Abstract

The specific objective of this paper, as part of a larger research plan to assess the environmental impacts of animal agriculture operations, was to develop spatially refined estimates of atmospheric deposition of ammonium and nitrate to river basins of North Carolina over time. Three different sources of information were utilized: 1) National Atmospheric Deposition Network (NADP) and Clean Air Status and Trends Network (CASTNet) data on amounts of ammonium ion (NH4+) and nitrate ion (NO3-) deposited as rain and snow; 2) National Weather Service data on amounts of precipitation; and 3) CASTNet estimates of amounts of dry deposition of NH4+ and NO3- deposited as atmospheric gases and particles. The data were integrated within a Geographic Information System-based framework delineating the river sub-basins in North Carolina, using interpolation techniques to produce estimates for a 5 X 5 km grid. Because of limitations of funding, this initial analysis concentrated on only two years, 1989 and 1994.

We conclude from the analyses that: a) a substantial part of the scientific evidence is consistent with the hypothesis that recently increased populations of swine in NC have contributed to an increased transfer of NH4+ from the atmosphere to land and surface waters of the state, and b) a less substantial part of the evidence is not fully consistent with this hypothesis.

Five steps in further analyses are recommended: a) utilizing data for all years of the historical record, b) checking the temporal and geographical representativeness of NADP and CASTNet sites, c) conducting more detailed time-series analyses at all sites, d) considering dry deposition more adequately, and e) using nutrient deposition data as a critical test of emissions inventory methods.

ATMOSPHERIC DEPOSITION ESTIMATES OF NITROGEN TO THE ATLANTIC AND GULF COASTS OF THE UNITED STATES

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Abstract

General estimates have been developed for atmospheric deposition of nitrogen on coastal and estuarine waters of the eastern United States Atlantic Ocean and Gulf of Mexico. This study set out to develop and apply a methodology for using data collected by the National Atmospheric Deposition Program/National Trends Network (NADP/NTN) monitoring network to calculate estimates of atmospheric deposition of nitrogen to coastal waters. The methodology was developed to generate estimates of direct wet and dry deposition of ammonium, nitrate, and total inorganic nitrogen to surface waters and indirect deposition of nitrogen to surface waters.

The findings presented in this report reflect the completion of the first part of this study - the calculation of direct wet deposition of ammonium, nitrate, and total inorganic nitrogen to coastal and estuarine waters of the U.S. portions of the Atlantic coast and the Gulf of Mexico.

The general approach for defining the study area was to generate an initial zone from the shoreline, extending a specified distance out into the ocean. This zone was segmented for estimation and reporting purposes based on the National Oceanic and Atmospheric Administration's (NOAA) Coastal Assessment Framework (CAF), an existing digital set of spatial areas developed by NOAA's Strategic Environmental Assessments (SEA) Division.

Annual and seasonal deposition data available from NADP/NTN were used to estimate direct loadings and concentrations of nitrogen from wet deposition. A Thiessen algorithm was used to define the area for which data collected at each NADP station are valid. Direct wet deposition loads of nitrate, ammonium, and total inorganic nitrogen and the concentrations of these species in rainfall were derived from NADP/NTN data. This analysis extrapolates data from monitoring sites to generate estimates for coastal and estuarine surface water segments.

STABLE NITROGEN ISOTOPIC TRACERS OF SOURCES OF NITROGEN IN WET DEPOSITION ON THE NORTH CAROLINA COASTAL PLAIN

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Abstract

Human activities have increased the concentration of nitrate in ground waters and increased the loading of new nitrogen in rivers, estuaries and coastal waters. The pollution of the hydrosphere and the atmosphere by compounds of nitrogen is a problem that is a population-increase driven component of global change. [redacted] To distinguish between urban and rural sources, the $\delta^{15}N$ isotopic composition of NH4 in rainfall from Raleigh, NC and a swine farm in Sampson County, NC was monitored to determine if ammonium deposited as wet deposition has a different isotopic signal at an urban and farm site. The average isotopic composition of ammonium in rainfall at the Sampson County collector was 8.4 per mil with a standard deviation of 3.92 per mil. The average isotopic composition of ammonium in rainfall collected at Raleigh was 4.9 per mil with a standard deviation of 2.1 per mil. The ammonium concentration in the Sampson County rainfall was twice as high as in Raleigh rainfall, but the Raleigh rainfall contained more nitrate. Isotopically, the most negative ammonium was found during the winter months at the farm site. The highest concentrations of ammonium was found in the rain at the farm site during the summer months. This data suggests that the nitrogen isotopic composition of ammonium in rainfall can be used successfully to determine the extent of atmospheric deposition of nitrogen derived from animal waste lagoons. Future work should include the isotopic characterization of coastal rainfall as well as a comparison of dry and wet deposition.

SEASONAL VARIATIONS OF NITRIC OXIDE FLUXES FROM DIVERSE PHYSIOGRAPHIC AGRICULTURAL SOILS IN NORTH CAROLINA

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Abstract

Emissions of nitric oxide (NO) were determined during late spring and summer 1995 and the spring of 1996 from four crop types, located at four different physiographic regions in North Carolina. Emission rates were calculated using a dynamic flow-through chamber system coupled to a state-of-the-art mobile laboratory for in-situ analysis. Average NO fluxes during late spring 1995 were: 50.9 ± 47.7 ng N m^{-2} s^{-1} for corn in the lower coastal plain. Average NO fluxes during summer 1995 were: 6.4 ± 4.6 and 20.2 ± 19.0 ng N m^{-2} s^{-1} respectively for corn and soybean in the coastal region; 4.2 ± 1.7 ng N m^{-2} s^{-1} for tobacco in the piedmont region; and 8.5 ± 4.9 ng N m^{-2} s^{-1} for corn in the upper piedmont region. Average NO fluxes for spring 1996 were: 66.7 ± 60.7 ng N m^{-2} s^{-1} for wheat in the lower coastal plain; 9.5 ± 2.9 ng N m^{-2} s^{-1} for wheat in the coastal plain; 2.7 ± 3.4 ng N m^{-2} s^{-1} for wheat in the piedmont region; and 56.1 ± 53.7 ng N m^{-2} s^{-1} for corn in the upper piedmont region. An exponential dependence of NO flux on soil temperature was present at all of the locations. Further, all locations displayed a diurnal trend of NO emissions which revealed a peak in NO emissions that coincided with the maximum soil temperature for the day. The composite data of all the research sites revealed a general positive trend of increasing NO flux with soil water content and extractable nitrogen.

NITRIC OXIDE FLUX FROM SOIL AMENDED WITH MUNICIPAL WASTE WATER BIOSOLIDS: A STATUS REPORT

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Abstract

The flux of nitric oxide (NO) from soil amended with municipal waste water biosolids is studied in ongoing laboratory experiments and field observations. Much of the more than six million dry metric tons of municipal waste water biosolids produced annually nationwide is not contaminated with harmful heavy metals or persistent organics and thus potentially is useful as a nitrogen fertilizer and soil conditioner. The attraction is to take advantage of the benefits of these materials while protecting public health and the environment; if NO flux from municipal waste water biosolids-amended soil is less than the NO flux from chemically fertilized soil the argument for expanding the practice of spreading municipal waste water biosolids to soil would be enhanced; if NO flux from municipal waste water biosolids-amended soil is greater than NO flux from chemically fertilized soil the argument for expanding the practice of spreading municipal waste water biosolids to soil would not be enhanced.

Newly developed laboratory equipment and ongoing procedures are discussed and the results of preliminary laboratory NO flux experiments are summarized in terms of selected soil temperature and moisture conditions. The laboratory results will be compared to scheduled field observations and evaluated in terms of atmospheric transport, transformation and fate of NO and subsequent ozone formation.

NITRIC OXIDE FLUX FROM SOIL AMENDED WITH MUNICIPAL WASTE WATER

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Abstract

The flux of nitric oxide (NO) from soil amended with municipal waste water is studied in laboratory experiments and compared to NO flux from un-amended soil. Land application of municipal waste water is practiced throughout the US in efforts to dispose of the waste water while reclaiming the water and its nutrients for non-food chain and human food chain crop production. Historically nitrogen losses from these engineered soil systems have been discussed only in terms of liquid migration to surface and subsurface water supplies. The focus of this research is on the loss of gaseous nitrogen to the lower levels of the troposphere with the attendant problem of ozone formation.

Newly developed laboratory equipment and procedures are presented and discussed, and the results of experiments are summarized. These results indicate that NO flux from an un-amended sandy loam soil at field moisture ranges from 0.3 to 0.4 ngN/m^2s, NO flux from soil of different moisture contents ranges from 0.4 to 0.7 ngN/m^2s, and NO flux from soil amended with municipal waste water ranges from 1.0 to 1.2 ngN/m^2s. These results are compared to other research efforts which focus on field observations of NO flux from agricultural soil.

NITROUS OXIDE EMISSION FROM A SPRAY FIELD FERTILIZED WITH LIQUID SWINE EFFLUENT

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Abstract

Contemporary agriculture is characterized by the intensive production of livestock in confined facilities and land-application of stored waste as an organic fertilizer. Emission of nitrous oxide (N_2O) from receiving soils is an important, but poorly constrained term in the atmospheric N_2O budget. In particular, there are few data for N_2O emissions from spray fields associated with industrial scale swine production facilities that have rapidly expanded in the southeastern United States. In an intensive, 24 d investigation over three spray cycles, we followed the time course for changes in N_2O emission and soil physicochemical variables in an agricultural field irrigated with liquid lagoonal swine effluent. The total-N (535 mg L^{-1}) of the liquid waste was almost entirely NH_4^+-N (>90%) and thus had a low mineralization potential. Application of this liquid fertilizer to warm (19 to 28°C) soils in a form that is both readily volatilized and immediately utilizeable by the endogenous N-cycling microbial community resulted in a sharp decline in soil NH_4^+-N and supported a rapid and short-lived (days) burst of nitrification, denitrification and N_2O emission. Nitrous oxide fluxes as high as 9200 μg N_2O-N g_{dw} $soil^{-1}$ h^{-1} were observed shortly after fertilization, but emissions decreased to prefertilization levels within a few days. Total fertilizer N applied and N_2O-N emitted were 29.7 g m^{-2}, and 395 mg m^{-2}, respectively. The fractional loss of applied N to N_2O (corrected for background emission) was 1.4%, in agreement with the mean of 1.25% reported for synthetic fertilizers. The direct effects of fertilizer application appear to be more immediate and short-lived for liquid swine waste than for manures and slurries that have a slower release of nitrogenous nutrients.

CONTROLS ON DENITRIFICATION RATES IN SOILS FERTILIZED WITH LIQUID SWINE EFFLUENT

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Abstract

Two approaches were used to characterize physicochemical factors which affect the rate of denitrification in soils from a representative, effluent-amended agricultural field. First, intact soil cores (0 to 20 cm) were amended with effluent at three different loading rates in laboratory incubations. Fertilization produced a short-lived (1 to 2 d) burst of denitrification, with rates as high as 11,000 $\mu g\ N\ m^{-2}\ h^{-1}$ recorded (acetylene block technique) for the highest dose. Overall, higher doses gave higher rates of denitrification and prolonged the duration of the elevated gaseous N flux ($N_2 + N_2O$). Denitrification rates returned to prefertilization levels after a few days, despite NO_3^--N accumulation in the soil. This suggested that other factors might be rate-limiting in the short term. Therefore, the second component of this study focused on the effects of individual physicochemical variables (soil moisture, temperature, labile-C and NO_3^--N) on the rate of denitrification in homogenized soils in a laboratory setting. Moisture (a proxy for aeration status) significantly affected denitrification, as rates increased exponentially with increasing % WHC and leveled off at saturation. Nonetheless, appreciable rates of denitrification were observed at low soil moistures, highlighting the importance of denitrification at anaerobic microsites. In the presence of added labile-C or NO_3^--N, denitrifying enzyme activity (DEA) was stimulated 5 to 20-fold and by as much as 50-fold when the two treatments were combined. The temperature dependence of DEA followed a third order polynomial characteristic of microbial processes. An average Q_{10} value of 1.9 was calculated for DEA from an exponential fit of rates to temperature data over the range 7 to 35°C.

Session IV

COMPREHENSIVE MODEL TO STUDY ATMOSPHERIC NITROGEN COMPOUNDS

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Abstract

While much attention has been devoted to studying the role of oxides of nitrogen in the atmosphere and towards reducing their emissions, there has been little focus on the cycling of reduced nitrogen compounds (denoted NHx) in the atmosphere. The modeling of NHx cycling in the atmosphere is a relatively unexplored area of research. The primary confounding factors limiting such investigations have been the lack of understanding of the sources, sinks, and chemical coupling of NHx compounds in the atmosphere. The anthropogenic emissions of NH3 are still rather poorly quantified, while natural emissions are virtually unknown. Because NH3 emissions tend to be on the local to regional scale and the lifetime of NH3 is on the order of hours, the modeling framework adopted to study its cycling must have sufficient resolution. A model for the atmospheric behavior of NHx must also account for its interactions with aerosols and be able to describe both the atmospheric transport of NH3 near a source and the transport of NH4+ over long distances.

In order to synthesize the current knowledge of the processes governing the fate of NHx in a consistent modeling framework, the Regional Acid Deposition Model (RADM) was enhanced by adding several additional modules to represent the various atmospheric physical and chemical pathways governing the fate of emitted NH3. The resulting version of the model is referred to as the Extended-RADM. The model has the ability to dynamically represent the various competing process that interact to influence the cycling of reduced and oxidized forms of nitrogen and their interactions. Model applications over the eastern United States using 80-km grid resolution will be discussed. Preliminary predictions of the NH3/NHx ratio will be given. Preliminary model performance evaluations based on comparisons of model predictions (of both ambient levels as well as wet deposition amounts) with measurements and previous model simulations will be presented.

NITROGEN DEPOSITION AIRSHEDS FOR THE PAMLICO SOUND WATERSHEDS: DEVELOPMENT FOR OXIDIZED NITROGEN AND PRELIMINARY ESTIMATE FOR REDUCED NITROGEN

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Abstract

Atmospheric deposition of nitrogen is considered to be an important contributor to nitrogen loading of coastal estuaries. The loading comes (a) indirectly to the estuary through deposition first to the watershed and then release into streams and rivers and (b) directly to the estuary surface. Not only do we need to know the loading from the atmosphere to the watershed and estuary, but we also need to know from where the majority of deposition is coming, if we are interested in doing something about it. We use the concept of a principal airshed to define such a geographic region. We would like to know how big are the airsheds. Two principal forms of nitrogen explain the majority of deposition, oxidized nitrogen and reduced nitrogen. We expect differences between airsheds for oxidized nitrogen and reduced nitrogen because the former is associated with secondary products of photochemistry and the latter is associated with direct emissions. We would also like to know how different are the airsheds for the two principal forms of atmospheric nitrogen loading. The methodology developed for Chesapeake Bay is used to construct answers to these questions. A map of the Pamlico airshed for oxidized nitrogen, based on analyses with RADM, will be presented. The continental area, percent of oxidized nitrogen deposition explained and emissions density for the airshed will be given. For perspective, the Pamlico airshed will be compared with airsheds defined for Delaware Bay, Altamaha Sound, and Chesapeake Bay. Preliminary comparisons between the range of influence of oxidized nitrogen and reduced nitrogen, based on the Extended RADM, for select emissions regions will be presented. Assuming the average relation holds across space, a preliminary estimate of the reduced nitrogen airshed for Pamlico watershed will be presented.

MEASUREMENT OF AMMONIA/AMMONIA FLUX AND DRY DEPOSITION VELOCITY ABOVE NATURAL SURFACES IN EASTERN NORTH CAROLINA

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Abstract

Until recently ammonia has been relatively ignored as a primary pollutant in the United States. There have been some recent advances in the ambient concentration measurement of technology, specifically continuous-flow denuders, that have made it possible to accurately determine dry deposition rate of ammonia and its primary atmospheric reaction product, aerosol ammonia. Due to rapid growth of animal (hog) farms, eastern North Carolina experiences higher level of ammonia and ammonium. The primary focus of our work will be on the vertical fluxes of ammonia and ammonium and their dry deposition velocities over natural surfaces downwind of some typical natural/anthropogenic sources in eastern North Carolina.

Ambient ammonia concentrations are measured using traditional annular denuder systems and the continuous-flow wet denuder system. Ammonia concentration, temperature, and velocity measurements are made at two heights above the canopy/surface. The gradient method and the modified Bowen ratio method are used to estimate the sensible heat flux and ammonia flux. Dry deposition velocity (v_d) is estimated using the following definition: $v_d = \overline{F}_c \, \overline{c}$ where F_c is the total flux of the tracer mass (i.e. ammonia) and $\overline{c}$ is the mean concentration of the tracer mass near the surface.

The result of the experiment will provide improved parameterization of dry deposition of ammonia and ammonium in regional air quality models, which can be used to determine transport, transformation, and deposition of atmospheric nitrogen compounds in eastern North Carolina.

QUANTIFICATION OF ATMOSPHERIC NITROGEN DEPOSITION IN EASTERN NORTH CAROLINA USING THROUGHFALL AND BULK DEPOSITION COLLECTORS

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Abstract

No historical records exist for the dry deposition of ammonia (NH_3) and ammonium aerosols in eastern North Carolina. Throughfall and bulk deposition collectors were used to obtain an indirect estimate of dry deposition of nitrogen (N) to deciduous forest canopies in the immediate vicinity of a large-scale swine production facility (Eastern Farm site) in the Neuse River Basin, and along a NE-SW transect from Goldsboro, NC to the Bladen State Forest. At the Eastern Farm site, NH_4-N dry deposition was approximately 2x (10.2 kg N ha^{-1}) that from wet deposition during the period August 6, 1997 to April 16, 1998. Enhanced dry deposition of chloride (9.2 kg Cl ha^{-1}) and sulfate (17.1 kg SO_4 ha^{-1}) was also associated with the dry deposition of NH_4-N. Total N loading at forested sites along the transect ranged from 7.2 to 13.1 kg N ha^{-1} for canopies < 3 kms of animal production facilities versus 3.8 to 5.2 kg N ha^{-1} for canopies > 5 kms from such facilities. Enhanced dry deposition of Cl and SO_4 was also observed for canopies < 3 kms of animal production facilities. This research demonstrates that use of bulk deposition and throughfall collectors provides one means to access the potential of enhanced dry deposition of N in eastern North Carolina due to the presence of a relatively high-density of animal production facilities.

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Session V

ATMOSPHERIC NITROGEN DEPOSITION TO THE NEUSE RIVER BASIN: ANNUAL BUDGET AND SPATIOTEMPORAL VARIABILITY

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Abstract

Atmospheric deposition of inorganic N (DIN) through both wet and dry deposition of NOy, NH3/NH4+, and organics may contribute a large fraction of the total N flux to the waterways of the Neuse River watershed. Eutrophication leading to N-sensitive waters such as the Neuse River Estuary has been associated with changes in microbial and algal community composition and function (harmful algal blooms), hypoxia/anoxia, and fish kills. In an ongoing study, we quantified the weekly wet and dry deposition of inorganic and organic N at ten sites on a northwest-southeast transect in the watershed from 1996 to 1998. Data from an earlier study and preliminary organic data from this study showed that the DON flux in the coastal region is approximately 20% of the total wet AD-N flux. Deposition varied by up to 4 orders of magnitude, with the mean total (wet DIN +dry DIN+ wet organics) AD-N flux estimated at 2026 mg/m2/yr (32,493 tonnes/yr). Seasonally, the highest total weekly N deposition occurs during the summer months; this does not mirror the seasonal precipitation patterns and is likely driven by a combination of other meteorological forcing factors and seasonal changes in N emissions. Conservative estimates of watershed N retention reveal that this flux contributes up to 30% of the total N reaching the waterways of the basin.

THE ROLE OF ATMOSPHERIC N DEPOSITION IN COASTAL EUTROPHICATION: CURRENT ISSUES AND PERSPECTIVES

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Abstract

The atmosphere is a large and growing source of nitrogen (N) enrichment in N-sensitive estuarine and coastal waters experiencing accelerating algal production (eutrophication) and water quality declines (hypoxia, toxicity, fish kills, etc.). Regionally and globally. urbanization, agricultural and industrial growth in coastal airsheds are responsible for chemically-diverse N emissions; long-term (>10 years) atmospheric deposition records (NADP) indicate that specific forms of atmospheric N are increasing at relatively high rates. In particular, ammonium (NH_4^+) deposition associated with expanding livestock operations and their N-rich wastes has increased. Both increases in and changing proportions of various new N sources play roles in the structuring of algal communities, and may promote major biotic changes, including the proliferation of nuisance blooms. We are examining group-specific responses of the phytoplankton community (species composition, productivity) to a range of anthropogenic N compounds, including those in atmospheric deposition, in the eutrophying N-limited Neuse River-Estuary and adjacent Atlantic coastal waters. This research approach provides the functional nexus between increasing and changing forms of anthropogenic N loading, accelerating primary production and alterations at the base of coastal food webs, features commonly observed but not well-understood in eutrophying coastal waters. Results are applicable to nutrient assessment and management in geographically-diverse coastal waters experiencing various symptoms of nutrient over-enrichment.

AN OBSERVATION-BASED GAUSSIAN DISPERSION MODEL FOR DETERMINING AMMONIA EMISSIONS FROM A COMMERCIAL HOG FARM

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Abstract

In recent years, a great deal of attention has been given to the emissions and fate of nitrogen compounds in North Carolina, particularly with respect to ammonia emissions from livestock production facilities. Unfortunately, there is a general lack of reliable emission factors for these facilities. Several researchers have undertaken efforts in cooperation with the North Carolina Division of Air Quality to obtain more reliable estimates of ammonia emission factors, especially in terms of diurnal and seasonal variability.

In 1997, the Division of Air Quality installed two chemiluminescent ammonia monitors at a commercial hog farm where researchers had been measuring ammonia emissions, and meteorological measurements were being made. These concentration and meteorological measurements have been applied to a site specific gaussian dispersion model to back-calculate ammonia emission fluxes. The geometric qualities of this model allow the examination of the waste lagoon and the animal housing units; as a whole source or separately, depending upon wind direction.

Results are presented for diurnal and seasonal variability of the combined sources, and the relative source strengths of both the waste lagoon and the animal housing units. The source strengths are also examined with respect to meteorological variables.

DEVELOPING MULTI-MEDIA COUPLINGS TO LINK AMBIENT METEOROLOGICAL INFORMATION WITH THE DEPOSITION SURFACE ENVIRONMENT

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Abstract

Deposition of a chemical specie, such as nitrogen or any other VOC, is strongly dependent on the surface conditions. Humid surfaces and warmer surfaces tend to be good sinks for atmospheric pollutants. Indeed estimates for deposition flux rely on the surface conditions such as relative humidity and wetness, particularly for vegetative surface such as lawns in urban environment and agricultural lands in rural settings. For most cases, the data used for estimating these thermodynamic conditions are from the ambient measurements made at 2m above the surface (tower observations or model analysis). We test the hypothesis that the surface environment can be significantly different than the ambient environment. We then develop relations that would link the multi-media setting of air and the depositing surface boundary layer using a set of closed equations. These physiologically-based coupling relations are linked in a atmospheric boundary layer model and tested for different humidity estimates in the atmosphere and the corresponding surface humidity. Sample calculations regarding the differences in the surface flux with the additional surface information are also presented. This new model is of significant utility particularly for chemical deposition to vegetative surfaces, evapo-transpirative analysis in regional watershed, as well as for pest management.

MODELING AMMONIA EMISSION FROM SWINE ANAEROBIC LAGOONS

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Abstract

Ammonia emission from anaerobic swine lagoons is an important issue regarding potential air pollution and potential deposition of N at other locations. A model is needed that can predict ammonia emission using basic parameters that can be easily measured. This paper will summarize various models and methods that have been used for determining ammonia emission from lagoons, manure slurry storage pits or tanks, and flooded soils. Although turbulence and stability of the atmospheric boundary layer has influence on ammonia emission from lagoons, the objective of the paper is to evaluate whether a model using only four easily-measured parameters can be useful.

The model assumes that ammonia emission is influenced by four primary factors: the lagoon liquid's total ammonia concentration, pH, and temperature near the lagoon surface, and wind speed. The ammonia emission model is based on chemical and volatilization aspects. The chemical aspects of the model deal with the NH4+/NH3(aq) equilibrium in lagoon liquids. The dissociation reaction of ammonium ions into free ammonia is a first-order reaction. The transfer of NH3 across the liquid-air interface of lagoon systems is characterized by a first-order volatilization rate constant, which is based on the two-film theory, and estimated using equations from literature data that require wind speed and temperature. By combining the chemical dynamics of the NH4+/NH3(aq) system with transfer of gaseous NH3 across the interface, an equation was developed to determine the NH3 emission rate from swine lagoons as a function of the four primary factors. The interactive effects of the four factors can be studied by individually varying one factor while maintaining the three other factors at their mean values. It is seen that with the increase of factors such as pH, temperature, or wind speed, the NH3 desorption rate is increased appreciably.

The model results will also be compared to ammonia flux data from field experiments using two different methods to measure ammonia volatilization: (1) a floating chamber method used by Dr. Viney Aneja's research group at four or more swine lagoons with various total ammonia concentrations, and (2) a micrometeorological method used by Dr. Lowry Harper at three swine lagoons. Dr. Harper has developed a statistical regression model from his data using the same four parameters used in our model: liquid temperature, pH, and total ammonia concentration, and wind speed. Thus, sensitivity of Harper's regression model and our two-film model to changes in the four parameters can be evaluated.

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AN INTEGRATED DYNAMIC, PHYSIO-CHEMICAL APPROACH TO ASSESSING THE TRANSPORT AND DEPOSITION OF CHEMICAL SPECIES IN EASTERN NORTH CAROLINA.

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Abstract

There is an increasing interest regarding the fate of nitrogen compounds locally emitted in the southeastern United States. The problem is particularly complicated in agricultural portions of watersheds where the land boundary can function as both a significant sink and source for atmospheric nitrogen. A quantitative assessment of this boundary condition both from the context of the regional atmospheric nitrogen budget and with respect to the variability of local atmospheric nitrogen deposition would constitute a significant improvement in the region's the cycling of nitrogen within its watersheds.

For a preliminary assessment, we have selected the coastal plain of North Carolina. Surface meteorological observations from over 20 weather stations across North Carolina for three periods: July 2-7 1998, October 5 - 11 1998, and December 12 -19 1998, are being analyzed. The first analysis objective is to understand the diurnal and, possibly, seasonal features of the wind field over eastern North Carolina. This mesoscale information allows insights regarding the trends and deviations possible in the dynamic trajectories of locally emitted nitrogen compounds. Using a tracer model, trajectories related to these days are also analyzed assuming a unit source strength ground release first in the northeast and then southeast portion of the NC coastal plain. Using a Monte-Carlo approach, for a simple gaussian plume analysis, the ranges for surface concentrations are obtained to complement the trajectory data under different observed scenario.

Once the material is transported, its deposition depends on surface features, in addition to the atmospheric variables such as humidity and precipitation. To understand the deposition potential, a detailed planetary boundary layer (PBL) model with a non-local closure scheme is coupled with an ecologically intensive soil-vegetation-atmosphere-transfer (SVAT) scheme to calculate boundary layer and canopy resistance. These resistances are used to determine the deposition velocity and the range of potential deposition flux for land types in eastern North Carolina.

Session VI

CONTROLLING ATMOSPHERIC EMISSIONS FROM ANIMAL WASTE TREATMENT: CHALLENGES AND OPPORTUNITIES.

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Abstract

Based upon EPA and USDA estimates, from two-thirds to more than 90% of the nitrogen in hog waste is volatilized as ammonia when the waste is treated in anaerobic lagoons and land applied via high pressure spray application. Current research efforts are ongoing to provide a better estimate for the systems and climate in North Carolina. Notwithstanding the anticipated revisions as a result of this research, there is no doubt that modifications of the current waste treatment technology to contain the atmospheric loss of nitrogen will either increase the amount of land required for waste treatment, if all the animal waste is to be land applied, or require reductions in herd size. Currently available information would indicate that from 3 to 10 times as much land could be required to grow sufficient crops to utilize all the nitrogen in animal waste if none where lost to the atmosphere.

On the other hand, the increased nitrogen concentration in the waste would improve the nutrient balance with phosphorus making a better fertilizer. The capture of nitrogen increases the value of the waste, allowing more economic recovery for the grower if the right market can be found. Odor control and energy production from methane are additional benefits which could be realized by techniques which reduce nitrogen volatilization. Realization of additional economic streams inherent in the manure could benefit both the grower and the local community in which he or she lives, as well as the environment. Strategies to transition from current waste treatment technologies to resource recovery technologies will be discussed.

ASSESSING THE FLUX AND BIOAVAILABILITY OF ATMOSPHERIC ORGANIC NITROGEN TO NORTH CAROLINA COASTAL ECOSYSTEMS.

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Abstract

Atmospheric organic nitrogen (AON) has recently gained attention as an additional and quantitatively significant, yet rarely assessed, source of atmospheric N loading to coastal and estuarine ecosystems. Little is known about its importance as a nutrient source for algal primary producers or its potential role in the eutrophication of marine systems. The flux and potential bioavailability of AON in coastal North Carolina (Bogue Sound) were evaluated using event-based collections and enrichment bioassays with natural algal communities. Mean dissolved organic N (DON) concentration for two years of rainwater samples analyzed using a high-temperature oxidation technique was from 2 to 4 μM, or approximately 10-20% of total N concentration. Annual DON deposition (wet only) was 10 % of total N deposition and was greatest for season and storm types with the most rainfall. Enrichment of coastal water with isolated rainwater DON produced increased phytoplankton biomass and carbon fixation, but not as large as the response to inorganic N additions. Bioassays suggest that a portion of the AON pool is available to primary producers on short (hours to days) time scales. The impact of AON on marine ecosystems over longer time scales and at natural loading rates requires further investigation.

GROUNDWATER CONTAMINATION OF PRIVATE DRINKING WELL WATER BY NITRATES IN HOMES ADJACENT TO INTENSIVE LIVESTOCK OPERATIONS (ILO)

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Abstract

Since October 1995, OEES has conducted a program established by the governor of North Carolina that samples for free any private well in the state adjacent to an ILO for nitrate contamination. As of August, 1998, 1,595 wells in 57 counties have been tested. 34.2% of the wells (546 out of 1,595) have exhibited nitrate contamination above 2ppm. 10.2% of the wells (163 out of 1,595) have exhibited nitrate contamination at/or above the drinking water standard of 10ppm and may pose an increased health risk upon consumption. Hog farms in several counties have been identified as the responsible party in the contamination of some offsite private wells. Hog lagoons and wastewater spray fields have been responsible for well contamination in these instances. The poor condition of private wells, especially in eastern North Carolina has exacerbated the nitrate contamination of many of the wells tested in this program.

Poster Presentations

COUPLED TRANSPORT AND CHEMICAL REACTION MODEL FOR AMMONIA EMISSION AT WASTE TREATMENT LAGOON-ATMOSPHERIC INTERFACE

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Abstract

Global emission of ammonia is approximately 75 Tg N/yr. The major source is excreta from domestic animals (~32Tg N/yr). Waste treatment lagoons are used to treat the excreta of hogs in North Carolina. Proteins and nitrogen rich compounds in the lagoon are converted to ammonia, through a series of biological and chemical transformation in anaerobic conditions. This ammonia is volatilized into the atmosphere. To investigate the process of ammonia emission, a coupled transport and chemical reaction model of ammonia across lagoon-atmospheric interface is developed. Analysis of flux is performed with two film model of transport. The equilibrium ammonia flux is determined with an empirical mass transfer approach. A sensitivity analysis is performed on the model. The model is validated using data collected from swine waste treatment facilities in NC.

ENVIRONMENTAL INFLUENCES ON NITRIFICATION IN SPRAY FIELDS FERTILIZED WITH LIQUID SWINE EFFLUENT

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Abstract

Microbial nitrification is an energy-yielding activity whereby NH_4^+-N is oxidized to NO_3^--N by specialized chemoautrotrophs. Nitrification provides substrate (NO_3^--N) for coupled nitrification-denitrification, whereby NO_3^--N is reduced by denitrifying microorganisms to N_2 and N_2O and lost from the ecosystem. The effects of temperature, moisture, dose and field type on the response of nitrifying bacteria was studied in intact soil cores (0 to 20 cm) amended with liquid lagoon effluent. In most cases, complete nitrification of added effluent (2.4 to 10 g NH_4^+-N) occurred within 10d from a field regularly irrigated with lagoon effluent, but not in soils from a fallow field. Nitrifying activity was localized in the 0 to 5 cm zone where most of the added effluent resided. The increase in NO_3^--N over the experimental time course accounted for roughly 80% of the total effluent-N added. Microbial immobilization did not decrease the accumulated NO_3^--N pool, pointing to the importance of crop utilization or denitrification to prevent off-site transport. The time-linear increase in NO_3^--N accumulation was used to calculate nitrification rates. Temperature, dose and field type (spray history) significantly influenced nitrification rates, while moisture level had no effect. Effluent -N is predominately NH_4^+-N (~90%) and therefore has little mineralization capacity. However, short term immobilization and subsequent remineralization of effluent-N may be important in determining the long-term availability of NO_3^--N.

COMPARISON OF EMISSIONS OF NITROGEN AND SULFUR OXIDES TO DEPOSITION OF NITRATE AND SULFATE BY STATE IN 1990

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Abstract

Many naturally occurring and human-induced activities result in the emission of nitrogen- and sulfur-containing compounds into the atmosphere. Precipitation is an important process by which compounds are scavenged from the atmosphere and deposited onto the earthís surface. The purpose of this paper is to compare the emissions of nitrogen oxides (NOx) and sulfur dioxide (SO2) in each of the 48 contiguous states in the USA with measured wet deposition of nitrate (NO3-) and sulfate (SO42-) in each state for the year 1990. With one exception (Vermont), wet deposition of N as nitrate was less than emissions of N as nitrogen oxides on a statewide basis in 1990. The median wet N deposition/emission value was 0.21. Wet plus dry N deposition of nitrate was estimated to represent 43% of NOx emission in North Carolina. Wet deposition of S was less than emissions in 1990 in all but five states (Vermont, Mains, Arkansas, Nebraska, and South Dakota). The median value of wet deposition of sulfate/SO2 emission was 0.34. In North Carolina, dry deposition of sulfate was estimated to represent an additional 21% of emissions, so that total deposition accounted for 60% of S emissions. Net transport of N and S is likely an important part of the discrepancy between emissions and deposition.

TRANSPORT AND FATE OF NITRIC OXIDE IN THE CLAY FRACTION OF NATURAL AND ENGINEERED SOIL SYSTEMS

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Abstract

The transport and fate of nitric oxide (NO) in the clay fraction of natural and engineered soil systems is studied in laboratory experiments and analyzed using sorption isotherm models. Nitrogen oxide emissions from soil result in the loss of valuable nitrogen as the nitrogen becomes unavailable to natural soil ecosystems and unavailable to engineered agricultural production and waste recycling systems. These nitrogen releases further can impact public health and crop production by catalyzing the formation of troublesome ozone (O_3). Consequently NO is studied here to gain a better understanding of its transport and fate in the clay fraction of natural and engineered soil systems.

Newly developed laboratory equipment and procedures are presented and discussed, and the results of experiments designed to monitor the transport, transformation and deposition of NO in soil are summarized. Selected sorption isotherm models are developed and applied to the laboratory results. These models are suggested to be useful methods for analyzing NO movement and deposition in natural and engineered soil systems. Methods to control the loss of nitrogen from the soil to the atmosphere are considered.

EVALUATION OF AVAILABLE CONTROL MEASURES, POTENTIAL EMISSION REDUCTIONS, AND COSTS OF CONTROL FOR ANTHROPOGENIC EMISSIONS OF NITROUS OXIDE

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Abstract

A number of emission control cost models have been developed for greenhouse gases. To date, these models have focused primarily on carbon dioxide (CO_2) emissions. The purpose of this effort was to develop cost and emission reduction information that will allow the incorporation of nitrous oxide (N_2O) control measures into overall global warming control models. N_2O is a greenhouse gas with an estimated global impact about 310 times that of carbon dioxide, for which concentrations have been increasing in the atmosphere. Anthropogenic sources of N_2O include the decomposition of waste from domesticated animals, the decomposition of nitrogen-based fertilizers, some combustion processes, and some industrial processes such as adipic acid and nitric acid manufacture. The present study identified a wide array of control measures for anthropogenic emissions of N_2O. Costs and potential emission reductions were calculated for measures with cost-effectiveness values of less than $200 per ton of carbon equivalent. Cost calculations indicated that some control of N_2O emissions would be achievable at a net cost savings.

FRACTIONAL PORTION OF CROP NUTRIENT REQUIREMENTS PROVIDED BY PRECIPITATION IN NORTH CAROLINA: TOBACCO AND LOBLOLLY PINE

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Abstract

Nitrogen and sulfur (and 14 other) essential nutrients are obtained by plants from both soil and atmospheric sources. This study using flue-cured tobacco and loblolly pine is the first assessment of the fractional part of nutrient requirements of North Carolina crops and forests being met from the atmosphere. Concentrations of SO42--S and both NO3--N and NH4+-N and precipitation amounts in 1992 were obtained from National Atmospheric Deposition Program/National Trends Network, in addition to precipitation amounts from the National Weather Service. Preliminary estimates of N and S dry deposition were made using data from three Clean Air Status and Trends Network sites in NC. County-level calculations show that: a) precipitation provided 55-122% (mean 77%) of the S needed by the tobacco crop; b) dry deposition of gases and aerosols provided 18-41% (mean 26%); and thus c) total (wet+dry) deposition provided about 73-163% (mean 102%) of the S required by tobacco in NC counties. Similar calculations for atmospheric inputs of N showed: a) 5-10% (mean 7%) from precipitation; b) 4-7% (mean 5%) from dry deposition; and thus c) total (wet+dry) deposition provided about 9-17% (mean 12%) of the N required by tobacco. These estimates should be considered 'potential' (upper-bound) estimates of tobacco nutrient needs being met by contemporary atmospheric sources. For loblolly pine, more than 100% (mean 159%) of sulfur requirements were met by wet deposition in 1992 in each NC county. Precipitation provided 5-9%(mean 6%) of N required by loblolly, while total (wet+dry) deposition was estimated to provide 9-16% (mean 11%).

ASSESSING THE FATE AND TRANSPORT OF ATMOSPHERIC NITROGEN AND VOCS IN NORTH CAROLINA: POTENTIALS OF THE NC ECO NET

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Abstract

One of the principal requirements in developing a realistic scenario regarding the transport and fate of nitrogen and other VOCs in North Carolina, has been the availability of accurate, continuous, representative, and easily accessible meteorological observations. Towards such a requirement, we present the concept and steps underway in developing the North Carolina Environment and Climate Observation Network (NC-ECO Net). The NC-ECO Net in its final phase will comprise of at least 100 automated weather stations (one per county) providing near real time agro-meteorological data for diverse applications such as dispersion and diffusion of nitrogen and other air pollutants and water shed management related issues in North Carolina. Significant technological and management related challenges need to be addressed. First, is integration of different networks (Climate Offices Ag Network; Forestry; NWS / FAA ASOS, AWOS, and others). The challenges in this integration are hardware related (instrumentation compatibility, data formats, communication protocols,..), and application related (data averaging time, data format, agency requirements). An inherent challenge in this is the communication cost using the traditional phone and modem based technology, as against satellite transmission for internet based data access which can link all the schools, community colleges, and different statewide agencies. The synergism in this combined approach of integrating all the measurement platforms, and developing the back and front-end protocol, and an effective dissemination system, will be extremely useful for environmental assessment, education, and natural resource management in North Carolina.

COMPARISON OF NITROGEN EMISSIONS AND DEPOSITION IN NORTH CAROLINA AND THE NETHERLANDS; SUGGESTIONS FOR A CONCEPT OF OPTIMUM NITROGEN MANAGEMENT FOR SOCIETY

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Abstract

So far, the processes of enhancing agricultural and forest production and making pollution-control adjustments in the industrial, commercial, agricultural, and transportation systems of society have proceeded in more or less complete isolation from concern about the environmental consequences of human alterations in the nitrogen cycle of the earth. Also, so far, most pollution abatement and mitigation strategies have been aimed at resolving one or another particular societal pollution problem in which oxidized and reduced forms of nitrogen play a part. The time has come to consider alternative, more fully integrated strategies and tactics by which to optimize societal efforts to maintain or increase agricultural and forest production while also enhancing the effectiveness and decreasing the cost of abating or mitigating various nitrogen-induced aspects of soil-, air-, and water pollution.

To explore these ideas more fully, we: (1) describe some important similarities and differences in nitrogen emissions and deposition and their probable impacts on agriculture, forestry, and surface and ground water quality in the Netherlands and North Carolina; (2) consider these similarities and differences in light of the theory of optimum nutrition developed by Tortsten Ingestadt in Sweden and adapted to ecosystem productivity by Per Gunderson in Denmark; (3) provide justification for adopting a total fixed nitrogen approach rather than continuing to deal with oxidized and reduced forms of nitrogen separately; (4) propose a concept of optimum nitrogen management for society; and (5) discuss these concepts in the context of the Multiple Pollutant/Multiple Effects Protocol soon-to-be-adopted by the United Nations Economic Commission for Europe (UN-ECE).