A Simulation-Optimization Aided Decision-Support System for Odor Management under Uncertainty

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University of Regina

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PROJECT LEADER

Gordon Huang

RESEARCH PERSONNEL

Yongping Li
Zhengfang Liu
Yiyong Liu
Dan Wang

EXECUTIVE SUMMARY

Odor problems associated with rapid social and economic development have been a critical concern facing both national and local governments around the world for several decades. The increasing odor issues could not only pose a variety of impacts and risks on public health, but also lead to significant vulnerability for sustainable regional development in the future. Moreover, the odor nuisance complaints against animal production farms are continuing to increase, and they are becoming one of the main barriers for expansion and development of livestock industry. Determining appropriate setback distances between neighboring residents and farms has become an urgent need for the livestock industry and regulating agencies. However, since odor emissions from animal production facilities are a function of species, housing types, feeding methods, manure storage and handling methods, the size of the odor sources, and weather conditions, defining appropriate setback distance becomes difficult because the setback distance depends not only on the source of facilities, dispersion and movement process of odor emissions, but also on meteorological conditions, odor sensitivity and tolerance of the neighbors. In addition, judging by complaints over agricultural odor issues, additional odor control measures or practices may be needed to control odors when existing operations meet odor setback distances.

Previously, several models were developed and applied to determine setback distance (e.g., Ontario MDS-II model lI, W-T model, Austrian model, Purdue model, OFFSET model), but none of them was widely used because of their strength and inherent limitations. In fact, determining the setback distance by a modeling approach is difficult since odor generation, emission and dispersion processes are often complex and poorly defined; moreover, the determination of setback distance is fraught with uncertain, dynamic and multiobjective features. Thus, effective examination, identification and reflection of the uncertainties, which is essential for generating high efficient and reliable outcomes, have been a major concern in the development of environmental modeling methodologies for supporting odor management under uncertainty. However, in odor management practices, there was a lack of incorporation of a variety of uncertain system components within a general decision-support framework. Moreover, most of the previous methods for odor management were lack of comprehensive considerations for processes of odor generation, mitigation, and dispersion, as well as the related risks and impacts.

Therefore, the objective of this effort is to develop a simulation-optimization aided decision-support system for odor management under uncertainty.
The objective entails:

- investigate the potential uncertainties in odor generation, emission and mitigation,
- propose two inexact simulation models to investigate fate and transport of pollutants in the atmosphere for supporting odor management,

- develop a set of inexact optimization models for reflecting many system uncertain components to support the odor management under uncertainty,
- perform post-optimality analysis based on fuzzy multi-criteria decision support sub-system for dealing with various policy issues and public concerns, and
- establish a simulation-optimization aided decision-support system for odor management, where a number of methods/tools of artificial intelligence, expert system, fuzzy logic, and cluster analysis, and geographical information system will be customized to effectively reflect the complex system characteristics.

This report consists of 7 chapters. Chapter 1 is an introduction. Chapter 2 provides literature review and background of this study. Chapter 3 presents two inexact simulation models to investigate fate and transport of pollutants in the atmosphere, and thus support odor management under uncertainty. One developed model is an inexact-stochastic Gaussian simulation model (ISGSM), which will incorporate approaches of interval analysis and Monte Carlo simulation within Gaussian dispersion model. the ISGSM is used for simulating pollutant concentrations from point source emissions under uncertainty The second developed one is a fuzzy-stochastic airshed model (FSAM), which introduces fuzzy set theory and stochastic methods into airshed model. Chapter 4 develops three inexact optimization models for odor management and planning under uncertainty. They are: (i) a hybrid fuzzy robust chance-constrained programming (FRCCP) model by allowing fuzzy coefficient A and fuzzy capacity B with random distribution to be effectively represented within the optimization process, (ii) an inexact two-stage stochastic programming (ITSP) method for reflecting uncertainties presented in terms of discrete intervals and random variables in odor management and planning, and (iii) an inexact fuzzy two-stage stochastic (IFTSP) model for handling uncertainties expressed as intervals, fuzzy sets, and probabilities in odor management problems. Chapter 5 provides post-optimality analysis (PMA) based on public participation and fuzzy multi-criteria decision support sub-system (FMCDSS). Based on the optimization solutions, the developed FMCDSS can generate and select out the feasible optimal decision alternative according to multiple criteria, incorporating many environmental, social and economic objectives which are of concern to a number of potential decision-makers. Moreover, within the PMA, public participation is involved to enhance for validating project inputs/outputs and thus generate desired decision support. Chapter 6 establishes an integrated decision support system for odor management (DSOM) to identify an optimal strategy under uncertainty. The DSOM consists of five modules, with each of them being offered as graphical user interfaces for the convenience of practical operation, and can be run in odor management system. Users can easily access resources within the system through menus and buttons that allow the selection of different options via user-friendly interfaces. Chapter 7 is devoted to a summary of this project.

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