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A Canadian initiative to develop an agri-environmental odour indicator

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Animal productions units are a dynamic and rapidly growing sector of the Canadian economy. Over the last thirty years, they have evolved from a diversified to specialized and intensified production systems. However, rapid growth has led to manure mismanagement, which has resulted in serious nuisance and environmental problems. The industrialization of animal production as well as demographic changes in rural areas has resulted into difficult cohabitation problems. Pollution and odours generated from livestock buildings, manure storages and land application activities are major causes of conflicts between producers and their neighbours. The environmental and social issues are presently the greatest challenge faced by Canada's fast growing livestock industry. As a result, in some regions across Canada the industry cannot take advantage of the increasing international market opportunities.

In response to the need for agri-environmental information and to assess the impacts of animal production on the environment, Agriculture and Agri-Food Canada (AAFC) began work on the development of a set of new environmental indicators. Agri-Environmental Indicators (AEIs) are primarily intended to provide reliable, science-based information on the current state and changes in the conditions of the environment in agriculture, at a national or regional scale. One of the indicators will address the odour issue.

A scooping paper was prepared. It describes the approach for the development of an odour environmental indicator. This paper discuss the suitability and feasibility of three broad areas for the development of an Odour Environmental Indicator - Pressure: pressure indicators can provide information on major farming stresses to populations, that can influence farm management decisions - State: state indicators can provide information on the main outcomes from farm activities, expressed either as risk indicators (estimate of potential environmental and social impact) or state indicators (measure of actual presence and degree of impact), and which are responsive to change in farm management practices. - Response: response indicators provide information on

the use by producer of various key management options which may influence the potential impact of agriculture on the social environment.

The paper discusses the development steps for the most appropriate type of indicator to address the serious odour issue associated with the livestock industries. The paper also discusses the data requirement and data gaps that need to be addressed in order to develop the odour environmental indicator.

KEYWORDS. Odour, indicator, nuisance, environmental impact, emission factor, livestock, animal feeding

1. INTRODUCTION

1.1 Issue

The industrialization of Canadian agriculture resulted in the expansion and the specialization of the farms as well as the intensification of the use of the land and other inputs. This new agriculture exerts environmental and social pressures stronger on the environment, and one of the consequences is the increase in the conflicts related to the odour issues.

The livestock operations are the activities identified mainly like sources of olfactive harmful effects (Huang and al, 2005). Some factors are structural like intensive livestock operations characterized by large-scale industrial facilities, the concentration of the operations, the rupture of the cycle between livestock production and crop production, and the manure management systems and practices. Moreover, urban sprawl is a factor of increasing land-use issues and conflicts.

The odours concerns are in general local issues. However, in some sectors, odours issues pose a direct constraint to growth.

1.2 Framework

In recent years, the agriculture industry has undertaken many initiatives to ensure its sustainability. The degradation of the resources threatens the growth of the farming sector and the environmental considerations represent direct constraints to certain agricultural activities. Objectives and indicators of progress and performance are thus necessary to guide the efforts to achieve a more-sustainable agriculture. For that purpose, Agriculture and Agri-Food Canada (AAFC) initiated the agri-environmental indicators (AEI) project in 1993.

This work was initiated in response to the necessity of getting agri-environmental information and evaluating impact of agricultural governments' policies on the environment. The National Agri-Environmental Health Analysis and Reporting Program (NAHARP) has been created to establish the capacity to develop and improve AEIs. Expert working groups in the area of soil, air, water, biodiversity, farm management practices/production intensity and food processing presently work on updating existing indicators, initiating the development of new indicators and assessing and identifying needs for eventual development of indicators. Among the new indicators proposed, one is related to agricultural odours.

The established indicators up to here seem sensitive to the evolution of the agricultural practices; they reveal national or regional trends and reflect the regional differences. They show the progress achieved in terms of sustainability of the agriculture, and the environmental risks related to the expansion and the intensification of the agriculture. They provide a baseline for comparison with future assessments of the situation. These results are encouraging, but all indicators have limitations related to gaps in data and our knowledge base, the quality of the data, and geographical limits. Indicators are designed to estimate changes and trends in time and space.

The AEIs are developed using information, which is taken mainly from the Soil Landscapes of Canada, with land use and farm management data from the Census of Agriculture and other custom data sets (from provincial agencies, private sector, remote sensing, etc.). Special surveys such as the Farm Environmental Management Survey (Statistics Canada, Agriculture Division 2002) are also used.

The types of AEIs defined by AAFC are in the Table 1. For each of the types of indicator, a baseline should be determined, to be able to estimate afterward the improvement of the agricultural practices and the efficiency of indicators (Lefebvre and al., 2005).

Table 1. Type of agro-environmental indicators defined by AAFC.

Type of agro-environmental indicator		Description
State indicator	(McRae et al., 2000) (Lefebvre et al., 2005)	Estimate of the actual presence and degree of an impact.
Risk indicator	(McRae et al., 2000) (Lefebvre et al., 2005)	Estimate of the likelihood of a potential environmental impact.
Response indicator	(McRae et al., 2000)	Identification and estimate of the presence of farm management practices modifying observed environmental impacts.
Eco-efficiency indicator	(Lefebvre et al., 2005)	Estimate of resource use efficiency, typically by comparing inputs and outputs of some material.

The three types of indicators, state, risk and response, defined in 2000 by AAFC (McRae and al., 2000) are relevant in the case of an odour AEI.

1.3 Objectives

The scoping paper addresses the need and feasibility to develop the odour indicator, as well as the required stages of development. The objectives are:

1. to establish a list of the Canadian farm activities that contribute to the emission of odorous gas, according to the results of a literature review on this subject and on the potential mitigation technologies and odour mitigation practices that could be applicable to the Canadian situation;
2. to assess the short and long term research priorities to address the knowledge gaps and to provide accurate odour emissions factors applicable to Canadian current farm management practices;
3. to assess the feasibility to develop an odour indicator and to propose a development approach.

2. Odour Emissions Characterization Methods

The impact of an odour and the likelihood of complaints result from five interacting factors, known as FIDOL factors: Frequency, Intensity, Duration, Offensiveness, and Location. These factors can be described as follow:

- The frequency (F) measures how often an individual is exposed to an odour.
- The intensity (I) refers to the perception of the odour strength or concentration.
- The duration (D) refers to the elapsed time over which an odour is experienced by an individual.
- The offensiveness (O) of the odour is the subjective rating of the pleasantness or unpleasantness of an odour.
- The location (L) accounts for the type of area in which are potentially affected people; and the type of activity they are engaged in.

The exposure to odour in ambient air is the result of odour emissions, air dispersion, and transport from source to receptor. This section reviews the practices for odour measurement, the techniques to collect samples and measure emission rates from the sources and the air dispersion modeling tools and methods.

2.1 Odour measurement: standards and methods

Odour measurement can be performed by sensory analyses or analytical techniques. Sensory tests concern the perceived effect of the odorants mixture as detected and interpreted by the human olfactory system. Analytical methods or physicochemical analyses relate to the properties of the odorants. The sensory methods have been chosen to develop standards for environmental odour measurement in many countries (Europe, United States, Australia, New-Zealand …).

3. ODOUR EMISSIONS SOURCES AND EMISSIONS CONTROL METHODS

In recent years, several literature reviews were conducted on odours emissions associated with livestock operations, and technologies and methods designed to reduce odour and gas emissions (Sweeten et al, 2006 ; Huang et al, 2005 ; AFOTW, 2004 ; Ortech, 2004 et 2005 ; Zhang et al., 2002 ; GEIS, 1999 ; Chapin et al, 1998). Some reviews identify the main sources and provide some emissions factors (Huang et al, 2005; AFOTW, 2004; Ortech, 2004). The pig industry is usually associated with odour issues in agriculture (Zhang et al., 2002 ; Groeneveld et Hébert, 2002 ; AAC, 1998).

3.1 Odour emissions sources and emissions rates

3.1.1 Odour emissions sources

The odours emissions resulting from animal production facilities come mainly of 1) the buildings ventilation, 2) the manure storage, 3) the activities of spreading and 4) the mortalities (Huang et al., 2005). Using fertilizing residual matters can generate odours as well as manures.

Some odours emissions sources in agriculture are pesticide application, composting for mushroom cultivation, the degradation of culture residues to the field (broccoli), rot during storage (potatoes).

3.1.2 Variability in emission rates

It is recognized in North America that there are gaps in protocols used to measure the emissions resulting from animal production facilities (NRC, 2002). Inappropriate characterization of operations is also a cause of variability in results. The ventilation system is usually not well described and analyzed.

A standard protocol is required to reduce variability in emission rates results. It may include factors associated with atmospheric conditions, ventilation and air quality in breeding houses and relevant parameters in breeding practices.

3.2 Odour management practices

Approaches to control odour emissions include (Sweeten et al., 2006):

1. Ration/diet modification: diet manipulation to reduce nutrient contents of manures may reduce gas emissions associated with manure storage and handling,
2. Manure management and treatment: products designed to cover earthen manure storage structures and trap gasses, chemical or biological manure treatment, manure injection and incorporation during the land application of untreated manure,
3. Capture/treatment of emitted gases: treatment of effluent gases from ventilation system in animal buildings,

4. Enhanced atmospheric dispersion: physical barriers or stack design.

4. PERSPECTIVES OF DEVELOPMENT FOR AN ODOUR INDICATOR

4.1 Feasibility

The three types of indicators are considered in the framework of the feasability study.

4.1.1 Data availability

The identification of the agricultural odour sources and the techniques of control is required, before any collection of data. The inventory of the activities emitting odours is possible mainly by means of statistical data of the agricultural census and the survey FEMS on the agro-environmental practices. The missing data can be obtained in the future, according to the adaptations and the necessary modifications identified.

The ranges are very wide for the data of listed emission factors (AFOTW, 2004) (Huang et al., 2005), and one of the main reasons would be the absence of normalized methods and standardized protocols. Generally, the emission factors approach is not accurate, and it is not recommended to extrapolate data from different situations and conditions. The priority is thus to standardize the methods and the protocols. It would be relevant to define a network of typical farms by region, on which the measures of specific rate of emissions in the Canadian situation could be performed. Methods of extrapolation of the values of factor of emissions could be also estimated in this type of installations.

4.1.2 Links with existing indicators

The AEI on air quality developed or in development are state indicators. Both indicators in development, on ammonia and particles, can have common methods and data with odour indicators. Ammonia indicator is particularly interesting….

It is appropriate to determine interactions between management strategies identified for both indicators in order to avoid favouring one approach within the two indicators that may have negative impact in respect to the perspective of the other indicator.

For each odour attenuation method, it would be adequate to assess its potential impact on other environment aspects. A preliminary evaluation grid has been proposed to classify this information and establish relationships with other AEIs. In developing an odour indicator, the evaluation grip should be updated to me compatible with sustainable development.

4.1.3 Identifying critical areas: nuisance risk indicator

It is not possible to implement an odour indicator to total Canadian territory. The odour indicator could be applied to some areas identified according to the odour nuisance risk assessment. Human density and type of animal facilities would allow defining the main areas, as the issues will not be the same in a low density area compared to a high density area and the management techniques will depend on the animal farm type. The nuisance risk indicator would be a tool to define the areas while developing and implementing the three potential odour indicators: response, state and risk indicator.

It would mean to establish the map identifying the potential problematic areas according to agriculture type and intensification and the human density.

4.1.4 Knowledge gaps

The main knowledge gaps are:

5. the lack of methods and protocols to characterize the facilities prior to evaluation of typical odour emissions and to measure properly odour emissions ;
6. the lack of study on the relation between odour impact and healt effects.

4.2 Development strategy

4.2.1 A response indicator

is possible on short and middle terms and could be based on adoption rate of practices to reduce odours in Canadian farms. As this type of indicator would not rely on field measurement campaigns and the efficiency of management techniques is variable from one facility to the other, the public concern would be useful to integrate in this type of indicator.

At this point, the response indicator proposed would be developed in three phases. The first phase would consist to evaluate the data needed. The second phase would provide the methods to calculate the response indicator and to establish the priority areas. The third phase aims to apply the indicator to some representative areas of different situations in order to test the method and to evaluate its efficiency and limitations.

On mid term, a **state indicator** could be developed, with statistic data on agriculture and emissions factors. This indicator would provide an odour level through a simple method to establish a value comparable between areas and over time. Dispersion modeling would evaluate the ambient odour level and the exposition frequency to odours.

A **risk indicator** would evaluate the occurrence probability of olfactive nuisance or impact assessment on human health. It could be combined with the response indicator development.

4.3 Model farms

On mid term, model farms offer a solution to get emissions factors representative of identified areas and conditions. The Danish (Riis, 2006) and American (NRC, 2002) approaches could be useful models.

5. CONCLUSION

The literature review on agriculture activities associated with odour emissions and odour management practices has shown the lack of methods and protocols to characterize the facilities prior to evaluation of typical odour emissions and to measure properly odour emissions.

A response indicator is possible on short term and could be based on adoption rates of odour management practices in Canadian farms. As this type of indicator would not rely on field measurement campaigns and the efficiency of management techniques is variable from one facility to the other, the public concern would be useful to integrate in this type of indicator.

On mid term, a state indicator could be developed, with statistic data on agriculture and emissions factors. This indicator would provide an odour level through a simple method to establish a value comparable between areas and over time. Dispersion modeling would evaluate the ambient odour level and the exposition frequency to odours.

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