ASSESSMENT OF THE AMMONIA ABATEMENT POTENTIAL OF DIFFERENT GEOGRAPHICAL REGIONS AND ALTITUDINAL ZONES BASED ON A LARGE-SCALE SURVEY

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ABSTRACT

Based on the results of a representative survey on farm management parameters relevant for ammonia emissions, a detailed assessment of the ammonia emission abatement potential in Switzerland was performed using the N-flux model DYNAMO. The available statistical data allowed the differentiation of nine different geographical regions and altitudinal zones. In accordance with the present situation, a technically possible and a realistically feasible reduction potential was assessed for different abatement measures. Under the present situation, extended grazing of dairy cattle followed by technical and organisational manure application measures offer the most efficient reduction potential. The reduction potential of covering open slurry stores is relatively low. The overall abatement potential for the combination of the four different abatement strategies results in an estimated realistically feasible reduction of approximately 20% of the ammonia emissions from livestock. Substantial differences of the abatement potential of measures could be observed between different geographical regions and altitudinal zones. The analysis allows to identify the most effective abatement measures specific for the different geographical regions and altitudinal zones and will be used for the preparation of practical recommendations on the most promising abatement measures specifically targeted to the different regions.
Keywords: *Ammonia emissions, abatement potential, manure management, survey.*

INTRODUCTION

Agricultural activity is well recognised as the major contributor of ammonia to the atmosphere. In Switzerland, emissions from agricultural sources were estimated to be 43.3 kt NH_3-N for the year 2000, thus accounting for over 90% of the total ammonia emissions (Reidy and Menzi, 2004). Mainly due to a significant decrease of the overall livestock numbers, agricultural ammonia emissions underwent a substantial reduction of 19% since the beginning of the nineties. Because of the still considerable negative impacts of ammonia, such as acidification and eutrophication of natural ecosystems, it is likely that in Switzerland measures for further reductions will be introduced in the foreseeable future. Ammonia emissions are strongly influenced by various farm management parameters and therefore depend on the prevailing production systems of specific geographical regions and altitudinal zones. As a consequence, the actual ammonia abatement potential as well as the most effective abatement measures may vary significantly between regions. Abatement strategies should therefore be adapted to the prevailing production systems in order to effectively and efficiently abate ammonia emissions. The assessment of the abatement potential and the most efficient abatement strategies is generally complicated by the lack of detailed statistical information on farm management parameters for distinct geographical regions. Available data mostly relies on the assumption of experts. The spatial resolution of such data is therefore usually insufficient to reliably reflect differences of farm management parameters relevant for ammonia emissions at a regional scale. To overcome these difficulties, we have developed a new approach to estimate the actual ammonia abatement potential of distinct geographical regions and altitudinal zones on the basis of the data from a

representative farm survey on farm management parameters relevant for ammonia emissions (Menzi et al., 2004). The stratified structure of the survey allowed a highly differentiated analysis of the ammonia abatement potential and the most effective abatement measures for nine distinct geographical regions and altitudinal zones.

MATERIALS AND METHODS

The representative survey on farm management parameters relevant for ammonia emissions was conducted within the framework of the work for the new Swiss ammonia emission inventory (Reidy et al., 2004). The data from 1'950 farms representative for three geographical regions (western, central, eastern Switzerland) and three altitudinal zones (lowland, hill region, mountain region) was considered for the determination of the present situation of the relevant farm management parameters (Table 1).

***Table 1**. Examples of farm management parameters influencing ammonia emissions during grazing, manure storage and manure application which were taken into account for the determination of the present situation.*

Emission stage	Relevant management parameters
Grazing	% of grazed animals, grazing days, grazing hours per day
Manure storage	% of slurry stored in uncovered stores
Manure application:	
Organisational measures	
Selection of application time	Frequency of manure application on hot, sunny days
	Frequency of manure application in the evening
	Frequency of manure application before/during rain
Consideration of soil conditions	Frequency of manure application during absorbent soil conditions
Seasonal planning of manure application	Proportion of manure applied during summer months
Manure distribution to different crops	Proportion of manure applied to specific crops
Dilution of slurry	Farmers perception and verification via amount of waste water collected
Technical measures	
Low-emission slurry application techniques	Proportion of slurry spread with low emission techniques

In accordance with the present situation, two different abatement levels were defined: (1) the technically possible abatement potential which considered all abatement measures that were technically possible according to the state-of-the-art as well as topographic and climatic limitations and (2) the realistically feasible potential which basically corresponded to the technically possible abatement potential reduced by taking into account factors limiting the applicability of a given measure in practice (e.g. social aspects, work load, availability of a given technique within reasonable distance, etc.). Economic considerations were excluded from the assessment. The two thus developed abatement levels were finally used for model calculations with the empirical ammonia emission model DYNAMO (Menzi et al. 2003). For each of the nine geographical regions and altitudinal zones the technically and the realistically feasible abatement potentials were calculated in absolute figures relative to the present situation. Aggregation of the data resulted in the estimated overall ammonia abatement potential for Switzerland.

RESULTS AND DISCUSSION

With a realistically feasible abatement potential of 8.8%, extended grazing of dairy cattle (implementation of the full grazing strategy) is estimated to offer the most efficient abatement strategy of the four most promising abatement methods in Switzerland (Table 2). This is mainly because under the current production systems, dairy cows, which are responsible for 51% of the ammonia emissions from livestock, are on average grazed only during nine hours per day (Reidy and Menzi, 2004). Implementation of the full grazing strategy therefore offers a promising possibility to reduce ammonia emissions effectively and with little or no additional expense. Covering of all open slurry stores would lead to a reduction of only 0.6%. Although this abatement method can reliably reduce emissions of individual farms significantly, the overall potential for Switzerland is insignificant because only one fifth of the Swiss slurry is kept in uncovered slurry stores. With an abatement potential of 12.5% (technically possible) and 7.6% (realistically feasible) of the ammonia emissions from livestock, the combination of all currently available technical measures to reduce ammonia emissions during manure application (applied in hierarchical order: rapid incorporation of slurry, deep injection, shallow injection, trailing shoes and trailing hoses) offer a potential similar to that estimated for extended grazing. Assuming that trailing hoses would also be used instead of the more efficient techniques (e.g. injection, an already considerable reduction of 5.9% (technically possible) or 4.9% (realistically feasible) could be achieved (data not shown).

***Table 2**. Technically possible and realistically feasible ammonia abatement potential of extended grazing, covering slurry stores and application measures. Values represent the potential for Switzerland as derived from model calculations for nine distinct geographic regions and altitudinal zones.*

Abatement method	Technical possible	Realistic feasible
	% of livestock ammonia emission 2000	
Extended grazing	10.8	8.8
Covering of slurry stores	0.6	0.6
Application: Technical measures	12.5	7.6
Application: Organisational measures	8.6	5.9
Grazing + storage + application	28.3	20.6

***Table 3**. Technically possible and realistically feasible ammonia abatement potential of technical application measures expressed in percent of the application losses of nine distinct geographical regions and altitudinal zones within Switzerland.*

Region	Altitudinal zone	Technical possible	Realistic feasible
		% of application losses	
Eastern	Lowland	38.1	24.2
Central	Lowland	35.6	20.8
Western	Lowland	42.5	25.0
Eastern	Hill region	17.6	9.6
Central	Hill region	18.8	10.6
Western	Hill region	20.9	9.1
Eastern	Mountain region	2.6	0.5
Central	Mountain region	3.5	0.7
Western	Mountain region	4.2	1.0

Interestingly, organisational measures during the application of manure such as the selection of a better application time and/or day, the seasonal planning of slurry application and the specific dilution of slurry seem to offer an abatement potential comparable to the one estimated for technical measures. The total abatement potential resulting from the combination of the four different abatement strategies considered in table 2 result in an estimated reduction of 28.3% (technically possible) and 20.6% (realistically feasible) of the total ammonia emissions from livestock. Due to the interdependence of the different strategies, the total abatement potential is slightly lower than the sum of the individual strategies. Depending on the prevailing production systems, the actual ammonia emission abatement potential of specific measures may vary significantly between different regions and altitudinal zones (Table 3). On the one hand, a strong altitudinal gradient can be observed for the technically as well as for the realistically feasible abatement potential. This is primarily because of an increasing proportion of steep surfaces at higher altitudes on which slurry application with low emission techniques is impossible. On the other hand, most striking for the lowlands, differences exist between regions within the same altitudinal zone. In the case of the central lowlands, the significantly lower realistically feasible potential reflects the comparatively high amount of slurry that is already applied with low emission techniques.

CONCLUSIONS

Thanks to the availability of statistical information on farm management parameters for distinct geographical regions, a highly differentiated analysis of the ammonia abatement potential is possible. Furthermore, the new approach allows to identify the most effective abatement measures specific for the different geographical regions and altitudinal zones. This information will be used for the preparation of practical recommendations on the most promising abatement measures specifically targeted to the different regions. As nitrogen input is strictly limited in Swiss agriculture by the agricultural policy, reducing emissions results in more N available for crops and thus in a potential benefit for farmers. A wide and rapid implementation of the recommendations derived from the project is therefore expected.

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