A novel support tool to mitigate nutrient and gaseous losses at dairy housing from EU-Atlantic Region

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Abstract
It is necessary to assess synergistic and appropriate mitigation options in order to reduce efficiently the environmental pollution derived from individual animal farms. This contribution aims to present a novel tool to assess the mitigation potential of different strategies on manure production, gaseous losses (NH_3, N_2O, CH_4) and nutrient balance (N, P, K, Zn, Cu, OM) at dairy facilities. The first preliminary case study results are also shown.

Introduction
BREF documents, in which environmentally friendly best available techniques (BAT) are reported, have been published on intensive rearing of poultry and pigs [1]. However, there is not official BREF document for dairy farming despite the increasing scientific and political interest. Within the BATFARM Atlantic Interreg Project (http://www.batfarm.eu/), it is aimed to set-up a novel model in which the application of different strategies will be assessed on dairy farms. This contribution is focused on the effect of such strategies on manure production, gaseous losses (NH_3, N_2O, CH_4) and nutrient balance (N, P, K, Zn, Cu, OM) at dairy facilities.

Material and Methods
Model description
The model is being set-up by intermediary approaches between traditional empirical and mechanistic models. All calculations are done on monthly and annual basis. Regionalizable values are adapted to national conditions in the Atlantic region (Spain, Portugal, France, UK, Ireland).

<u>Farm Characterisation:</u>
Cattle herd is classified into 4 groups: milking cows, dry cows, calves < 12 months and heifers 12-26 months. Each herd is managed either in confinement or grazing. If herds are confined, the type of stall (freestall or tie-stall, solid or slatted floor, deep-litter or cubicle system) will be assessed by users.
<u>Zootechnical data:</u>
Herd size and the annual milk yield have to be described by users. Nutrient intake (N, P, K, Cu, Zn) is calculated through default values related to diets based on grass silage/hay, maize silage or grazing. If herds are fed with total mixed rations (TMR), users will have to define the diets. Default values are used for body weights, nutrient retention (milk/meat) and manure production (solid manure or slurry).
<u>Emission factors:</u>
Ammonia emissions are assessed adapting the formula from swine to dairy cattle [2]. Enteric CH_4 emissions from confined and grazing animals are obtained from literature review and national inventories. IPCC Tier 2 default values are used to estimate N_2O and CH_4 emissions from manure management [3].
<u>Mitigation strategies:</u>
All mitigation strategies are classified into 3 groups: Nutritional (nutrient fitting, phase feeding or electronic collars for milking cows), Manure Management (manure removal system, removal frequency, water saving means) and Technological (deep pit aeration, curved slat mats and slatted floors with valves).

Case study
A typical dairy farm from the Basque Country (northern Spain) [4] was used to the simulation. Table 1 summarizes the main parameters of this farm, which were common to both scenarios (Table 2). Scenario A considered usual on-farm management practices in the Basque Country while Scenario B

simulated a feasible alternative situation. The climate in the region is defined as Maritime Oceanic (annual mean temperature, 15ºC; annual mean rainfall, 1029 mm).

Table 1. Dairy farm characterization

Parameters	Description
Herd Size	
Milking Cows	73
Dry Cows	14
Calves < 12 months	15
Heifers 12-26 months	15
Milk Yield, kg/cow/year	9,057
Animal Management	Total Confinement – No grazing
Feeding System Adult Cows	TMR
Feeding System Young Cattle	Component Feeding (CF) based on grass hay/silage
Milking System	Herringbone double line 2x8

Table 2. Description of Scenarios A and B in the case study

Parameters	Scenario A	Scenario B
Nutrition Milking Cows	16.5% CP	17.0% CP
Type of Facility	Freestall, Deep Litter and Concrete Floor	Freestall, Deep Litter and Slatted Floor
Slurry Removal System	Mechanical	Flushing Water
Slurry Removal Frequency	Daily	Monthly
Wash Water Reutilization	50%	No

Results

Model description

Main outputs of the model are: (i) Whole farm feed and water consumption; (ii) Whole farm nutrient balance (N, P, K, Cu, Zn, OM); (iii) Whole farm NH_3, N_2O, CH_4 emissions; (iv) Whole farm solid and liquid manure production and composition; (v) Farm effects on FIOs; (vi) Farm scoring (when two situations are compared).

Case Study

Scenarios A and B were simulated in relation to the following parameters: (i) Gaseous losses (NH_3, N_2O, CH_4) from manure management; (ii) Slurry production; (iii) Nutrient accumulation in slurry (N, P, K, Zn, Cu, OM).

<u>A) Assessment of gaseous losses (NH_3, N_2O, CH_4)</u>

Gaseous losses simulated in the current case study included either the emissions produced by slurry or solid manure accumulated indoors. Figure 1 and 2 shows the monthly NH_3 and CH_4 emission pattern. Ammonia emission decreased for Scenario B throughout the year (Figure 1) despite dietary CP content and slurry removal frequency were higher. The model estimated that default Scenario A would yearly produce 1,748 kg NH_3-N while emission would be reduced by 14.7 % on Scenario B. The type of floor (slatted floor) and the use of hose water for slurry cleaning reduced significantly NH_3 emission. Both scenarios were sensitive to seasonality as NH_3 emissions increased in summer (mean temperature, 21ºC). On the contrary, CH_4 emissions were significantly lower on Scenario A (Figure 2). Simulation estimated that 4,091 kg CH_4 would yearly be lost from manure management on default Scenario A.

Methane emission increased by 94.5% on Scenario B because of the longer storage time. The highest CH_4 emission peaks were also detected in summer period.

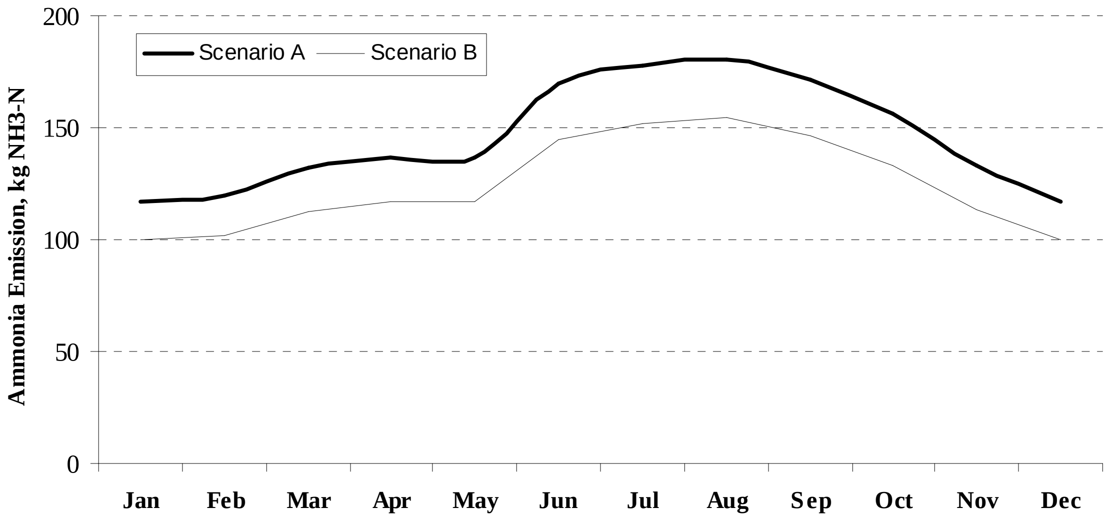

Figure 1. Ammonia emission pattern throughout the year under Scenario A and B

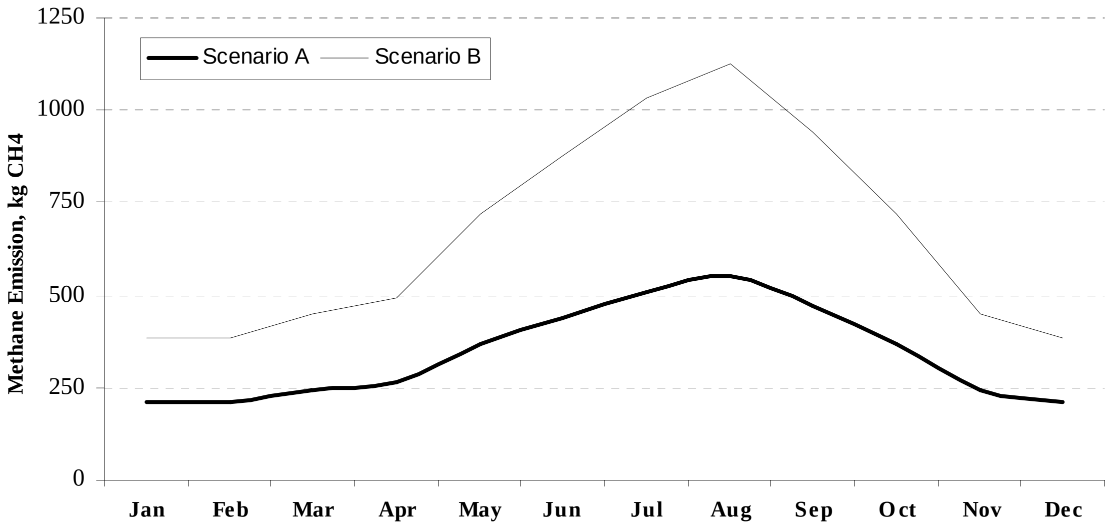

Figure 2. Methane emission pattern throughout the year under Scenario A and B

Nitrous oxide losses did not show a seasonal pattern as its emission is defined as low and is not temperature dependant at animal facilities. Therefore, the annual N_2O emission was 66.3 and 84.7 kg N_2O-N on Scenario A and B, respectively. This difference was attributed to the higher animal N excretion on Scenario B.

Slurry production.

Annual slurry production was estimated 1,587 and 2,630 tons on default Scenario A and Scenario B, respectively. This significant increase of slurry volume was account for either the flushing system or the lack of reutilization of wash water in the milking parlor. Despite flushing system can reduce NH_3 emission at stall, it contributes to a significant increase of slurry volume.

Nutrients Accumulated on Slurry:

Table 3 shows the nutrient accumulation on slurry after the simulation of both scenarios. The amount of N increased on Scenario B because of the higher N excretion and lower NH_3 emission. On the contrary, the amount of accumulated OM was lower for Scenario B due to the higher CH_4 losses. The rest of parameters (P, K, Cu, Zn) were not affected under this case study.

Table 3. Nutrients Accumulated on Slurry in Scenario A and B

Parameters	Scenario A	Scenario B
Nitrogen Accumulated, kg N/year	6,689	7,203
Phosphorus Accumulated, kg P/year	1,159	1,159
Potassium Accumulated, kg K/year	3,428	3,428
Copper Accumulated, kg Cu/year	4	4
Zinc Accumulated, kg Zn/year	16	16
Organic Matter Accumulated, kg OM/year	89,767	81,562

Conclusion and perspectives

This work integrates existing information on the potential of different environmental strategies to reduce manure production, gaseous losses (NH_3, N_2O, $CH_{4)}$ and nutrient accumulation at dairy facilities. The case study simulation highlighted the importance of selecting the best available technique regarding to a particular environmental pollution source (nutrient accumulation, gaseous losses or manure production. Further test will be necessary to validate the results provided by this tool.

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