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POSSIBILITIES OF REDUCING AMMONIA EMISSIONS FROM AGRICULTURE – SCENARIO FOR 2030[1]

Key words: ammonia emission, reduction of ammonia emissions, emission reduction potential, low emission practices, projection

ABSTRACT. The purpose of this study was to evaluate the possibility of ammonia emission reduction in 2030 by undertaking the activities specified in the “Advisory code of good agricultural practice for the reduction of ammonia emissions”. The methodology published by the European Environment Agency in 2016 has been used to estimate emissions. Projections were carried out for each type of category (animal production, use of mineral nitrogen fertilizers) and the total ammonia emission in 2030 was calculated, all results were compared to the base year 2005. Analyses have shown that the targets indicated in the NEC Directive would not be easy to achieve. Without the implementation of actions reducing ammonia emissions, it is expected that total emissions will rise by 2.7% by 2030. However, if we consider both emission categories separately, we can predict that NH_3 emissions will increase more than 45% from the use of mineral fertilisers and decrease by 6% from animal production. The most significant reduction in total ammonia emissions can be achieved through ploughing manure immediately (preferably within 4 hours) after application. Another technique involves the replacement of urea with ammonium nitrate (-12.4%) and the splashless application of slurry with parallel ploughing of manure (-11.0%) that gives ample opportunity to achieve a notable reduction.

INTRODUCTION

From 31 December 2016, the following Directive of the European Parliament and the Council of the European Union became applicable: *Directive 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC* [Official Journal EU L 344/1]. According to the requirements of the directive, Poland has been obliged to reduce its ammonia emissions by 1% for each year between 2020 and 2029 and by 17% in 2030 compared to 2005. The agriculture sector is the main source of ammonia emissions. The National Centre for Emissions Management (KOBiZE), which is responsible for the monitoring and inventory of ammonia and other air pollutant emissions in Poland, reported to the European Union in 2018, that the emission of ammonia from agriculture in 2015 and 2016 were 258.80 and 259.42 kt NH_3,

[1] The study was carried out as part of the task of the 2.6 Multiannual Programme 2016-2020.

respectively [KOBiZE 2018]. However, the international revision of national air pollution inventories, conducted under the NEC Directive in June 2018, recommended updating ammonia emission indicators for each category of mineral fertilisers according to the 2016 European Environment Agency Guidelines [EMEP/EEA 2016]. This update (indicators from the 2009 guidelines have previously been used) affected the increase of re-estimated ammonia emissions from agriculture, which in 2015 and 2016 were equal to 266.27 and 272.84 kt NH_3, respectively. Whereas ammonia emission in 2017 was estimated at 287.91 kt NH_3, that is about 94% of national emissions, 78% of which comes from livestock manure and the rest, 22%, is caused by the consumption of mineral nitrogen fertilizers [KOBiZE 2019]. In comparison to the previous year, about a 5.5% rise in emissions was noted. This change has mainly been related to an increase in the use of mineral nitrogen fertilisers (by 10%) and manure linked with livestock production. Given the continuous growth of ammonia emissions after 2015 from the agricultural sector (8%), fulfilling the commitments under the NEC Directive can be a challenge. A reduction annual target set at 1% in 2020 compared to 2005 emissions can be achieved under current policy and measures, whilst a 17% reduction in 2030 could be a challenge and, without further action, may not be achieved.

The realization of the imposed reduction targets demands an improvement in nitrogen management practices and the widespread promotion of low emission techniques allowing to limit ammonia emissions. For this reason, under the requirements of the NEC Directive, an Advisory code of good agricultural practice for the reduction of ammonia emissions was developed, describing numerous agricultural practices that can be used to reduce ammonia emissions [MRiRW 2019].

The study aimed to evaluate the activities specified in the Code, that could be undertaken in Polish agriculture, regarding the reduction of ammonia emissions in the time horizon 2030.

MATERIAL AND METHODS

The methodology used to estimate the emissions applied to international reporting and used by KOBIZE is provided by the European Environment Agency (EEA) and defined in the EEA/EMEP Emission Inventory Guidebook 2016 [EMEP/EEA 2016]. Total ammonia emissions from agriculture are the sum of both emissions from livestock production and the use of mineral nitrogen fertilisers. Ammonia emissions from animal production are estimated based on the size of the livestock population and information on their housing systems. The Tier 2 level (mass flow approach) method has been used to estimate ammonia emissions from manure. This method used an approach based on the Total Ammoniacal Nitrogen (TAN) flow concept in the animal husbandry system and allows to include selected techniques for ammonia reduction in the calculation of emissions. Applying the methodology at the Tier 3 level in the calculation of ammonia emissions, a more detailed variety of practices might be included, considering more livestock subcategories. More detailed information about the methodology of estimating ammonia emission from animal production can be found in the article by Zuzanna Jarosz and Antoni Faber [2019a].

Table 1. Input data for the projection of emissions in the agricultural sector

Activities	Units	2015	2020	2025	2030
Utilised agricultural area	thousand ha	14,000	14,600	14,500	14,350
Total sown area	thousand ha	10,675	10,550	10,425	10,300
Average annual milk quantity per cow	liter per year	5,200	6,800	7,500	7,900
Cattle populations:	thousand	5,800	6,000	6,100	6,200
- of which dairy cattle	thousand	2,500	2,300	2,000	1,800
Sheep and goat populations	thousand	300	250	210	180
Horse populations	thousand	290	280	260	250
Swine populations	thousand	9,750	10,350	10,400	10,500
Poultry populations	thousand	400,000	440,000	480,000	500,000
Nitrogen fertiliser consumption	thousand tonnes N	1,110	1,175	1,250	1,300
Agricultural organic soil management area	thousand ha	680	675	670	665
Main agricultural and horticultural production					
Cereals	thousand tonnes	28,650	29,700	30,000	30,000
Legume crops (edible, fodder)	thousand tonnes	475	520	570	600
Oilseed crops	thousand tonnes	2,590	2,900	3,000	3,000
Root crops (including potatoes)	thousand tonnes	20,800	20,650	20,450	20,300
Fruits	thousand tonnes	3,700	3,900	4,050	4,150
Vegetables	thousand tonnes	4,550	4,750	4,900	5,525
Maintenance system and share of grazing [% of the population]					
Dairy cattle	no bedding	75	65	45	30
	bedding	25	35	55	70
	pasture*	40	35	25	20
Meat cattle	no bedding	99	98	97	96
	bedding	1	2	3	4
	pasture*	98	90	87	85
Sheep	no bedding	100	100	100	100
	bedding	0	0	0	0
	pasture*	100	100	100	100
Horses	no bedding	100	100	100	100
	bedding	0	0	0	0
	pasture*	100	100	100	100
Swine	no bedding	65	35	30	25
	bedding	35	65	70	75
	pasture*	0	0	0	0
Poultry	no bedding	87	85	82	78
	bedding	13	15	18	22
	pasture*	0.1	0.2	0.3	0.4

* The percentage of the population using pasture was taken into account. The duration of the grazing period in the whole growing cycle was not taken into account.
Source: own study

Whereas ammonia emissions caused by using mineral nitrogen fertilizers are estimated based on the volume of their consumption, and the detailed methodology and indicators used in calculations were presented by Zuzanna Jarosz and Antoni Faber [2019b].

Using the forecasted changes in agricultural production in 2030, presented in Table 1, and reported to the Ministry of Agriculture and Rural Development in 2016 for the purposes of the Institute of Environmental Protection, which conducts activities related to the preparation of Government Reports to the United Nations Framework Convention on Climate Change (UNFCCC), has estimated emission changes from the base year 2005 in the context of the reduction measures specified in the Advisory code of good agricultural practice for the reduction of ammonia emissions. For the calculations of the range of NH_3 emission reductions provided in the Code, the lower value was used (the conservative approach).

All emission projections and reductions were calculated for each category type (livestock production and mineral nitrogen fertilisers), and total NH_3 emission potential was estimated.

RESULTS

The estimated ammonia emission from livestock production in 2030 without taking any reduction steps would be about 233.53 kt NH_3. Hence an emission decrease in relation to 2005 by 6.1% (Table 2). Nevertheless, the implementation of reduction activities pointed out in the “Advisory code of good agricultural practice for the reduction of ammonia emissions” would allow for a more significant limitation of emissions in comparison to the base year. As an example, the practice of covering manure and slurry completely would reduce emissions by -19.2 kt NH_3, and the immediate (within 4 hours) ploughing of manure and slurry by -60.7 kt NH_3 (Table 2). The immediate incorporation of natural fertilizers allows for a reduction in ammonia emissions by 60-90%. The effectiveness of this method decreases over time. Covering fertilizers 4 hours after application reduces emissions by 45-65%, and after 24 hours by 30% [Faber, Jarosz 2018]. The time and technique of manure application strongly influence the reduction potential of ammonia emissions [Reidy, Menzi 2007, Webb et al. 2010]. The use of sprayless slurry would reduce emissions by 35.8 kt NH_3 (-14.4%). Implementing the additional practice of manure ploughing at the same time would allow a further reduction of 56.3 kt NH_3 (-22.6%) (Table 2).

Ammonia emissions from mineral fertilizers depend on the type of fertilizer, soil and weather conditions (temperature, wind speed, precipitation) and application technique. One of the highest indicators of ammonia emission characterizes urea [EMEP/EEA 2016]. The losses of ammonia from urea have been estimated at 20-60%, with the highest values found when fertilisers are applied on the land surface (without mixing with the soil). In contrast, ammonia losses from ammonium nitrate vary between 2-10% of the total nitrogen applied [Marcinkowski et al. 2012]. As a consequence, the NEC Directive recommends replacing urea with ammonium nitrate fertilisers and adjusting the dose to the needs of the plant and richness of the soil. In the advisory code of good agricultural practice for the reduction of ammonia emissions we have listed three activities regarding the application of urea in Polish agriculture:

– replacing urea with ammonium nitrate,
– precision soil application of fertilizer based on urea,
– using urea with a urease inhibitor.

Assuming the consumption of nitrogenous mineral fertilisers in 2030 at a level of about 1,300 kt N/year (Table 1), and a coefficient value of ammonia emission equal to 0.057 kg NH_3/kg N [EMEP/EEA 2016], the emission, without taking any reduction measures, would reach 74.56 kt NH_3. Consequently, ammonia emissions between 2005 and 2030 would increase by 45.3% (Table 3). But the implementation of the above-described reduction practices could lead to a decrease of emissions in the range of -4% to -43% (Table 3). The biggest reduction of ammonia emission (-43.0%) can be achieved by replacing urea with ammonium nitrate. The effectiveness of this method is evaluated at 90% [Bittman et al. 2014]. However, a negative side result of this solution is the possibility that nitrous oxide emissions can increase, especially when ammonium nitrate fertilisers are applied on moist or wet soils. For this reason, using urea with a urease inhibitor is recommended. A reduction of ammonia emissions by 33.6% can also be obtained by the precise application of urea-based fertilisers on the soil.

According to the forecasted assumptions and without the implementation of any additional reduction activities, total NH_3 emission in 2030 would increase by 2.7% (Table 4). However, if we analyse both categories of ammonia emission sources separately, this means an increase by 45.3% from mineral fertilisers (Table 3), and a decrease by -6.1% from natural fertilisers (Table 2).

Table 2. Projection of ammonia emission reduction in 2030 from livestock production, as a result of the implementation of selected practices

Reduction practices	Change in emission 2005-2030	
	%	kt NH_3
Without any practices	-6.1	-15.17
Splashless spreading slurry	-14.4	-35.80
Ploughing manure and slurry within 4 hours	-24.4	-60.66
Ploughing manure within 4 hours	-14.0	-34.91
Splashless spreading slurry and ploughing manure	-22.6	-56.32
Covering slurry and manure	-7.7	-19.20
Low-protein dairy cattle feeding	-11.6	-28.93
Multi-phase all cattle feeding	-11.6	-28.85
Low-protein swine feeding	-9.9	-24.58
Two-phase feeding: pigs for fattening	-7.9	-19.52
Three-phase feeding: pigs for fattening	-9.6	-23.81
Low-protein chicken feeding	-9.9	-24.60

Source: own study

Table 3. Projection of ammonia emission reduction in 2030 from the application of mineral fertilizers, as a result of the implementation of selected practices

Reduction practices	Change in emission 2005-2030	
	%	kt NH_3
Without any practices	+45.3	+23.23
Replacing urea with ammonium nitrate	-43.0	-22.06
Precision soil application of fertilizer based on urea (limiting 50%)	-4.0	-2.08
Precision soil application of fertilizer based on urea (limiting 80%)	-33.6	-17.26
Using urea with a urease inhibitor	-23.8	-12.20

Source: own study

Table 4. Potential reduction of total ammonia emission in 2030 as a result of the implementation of selected practices listed in the Advisory code of good agricultural practice for the reduction of ammonia emissions.

Reduction practices listed in the Advisory code of good agricultural practice for the reduction of ammonia emissions	Change in emission 2005-2030 [%]
Without any additional practices	+2.69
Replacing urea with ammonium nitrate	-12.41
Precision soil application of fertilizer based on urea (limiting 50%)	-5.75
Precision soil application of fertilizer based on urea (limiting 80%)	-10.81
Using urea with a urease inhibitor	-9.12
Splashless spreading of slurry	-4.19
Ploughing manure and slurry within 4 hours	-12.48
Ploughing manure within 4 hours	-3.89
Splashless spreading of slurry and ploughing manure	-11.03
Covering slurry and manure	+1.34
Low-protein dairy cattle feeding	-1.90
Multi-phase all cattle feeding	-1.87
Low-protein swine feeding	-0.45
Two-phase feeding: pigs for fattening	+1.23
Three-phase feeding: pigs for fattening	-0.19
Low-protein chicken feeding	-0.46

Source: own study

The implementation of separate activities results in changes in predicted ammonia emissions from mineral fertilizers in 2030, showing that the replacement of urea and its mixtures with ammonium nitrate has the highest potential (-12.4%). Another significant reduction in NH_3 emissions could be achieved by using urea with an urease inhibitor (-9.1%). Precision soil application of urea fertilisers, depending on the method and related reduction values, might cause ammonia emission reductions between -5.8% and -10.8% (Table 4).

In the case of manure, the distribution of potential reduction compared with total ammonia emissions from agriculture is much broader: between +1.3% (covering 100% by manure and slurry) and -12.5% (ploughing of manure and slurry within 4 hours of application). Another significant reduction in NH_3 emissions (-11.0%) could be achieved by spreading slurry without splashing, combined with immediate manure ploughing (Table 4).

CONCLUSIONS

The conducted research showed the possibilities of ammonia emission reduction from agriculture in Poland in the perspective of 2030 through the implementation of different types of activities recommended by the Advisory code of good agricultural practice for the reduction of ammonia. One of the most significant NH_3 emission reduction potentials is attributed to immediate ploughing (preferably within 4 hours of application) of manure.

Note that, according to the requirements of the NEC Directive, national emissions of ammonia should not exceed a yearly reduction target fixed at 1% compared to 2005 emissions during the period 2020-2029. A security measure in this situation, when no other additional measures are applied, might be provided through the implementation of ploughing manure within 4 hours of application, resulting in a 3.9% reduction in 2030.

Concluding, the dissemination of knowledge and the implementation of reduction activities could contribute to a significant reduction of ammonia emissions in the future.

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MOŻLIWOŚCI OGRANICZENIA EMISJI AMONIAKU Z ROLNICTWA – PROJEKCJA NA 2030 ROK

Słowa kluczowe: emisja amoniaku, ograniczenie emisji amoniaku, potencjał redukcji emisji, praktyki niskoemisyjne, projekcja

ABSTRAKT

Celem badań było wskazanie możliwości ograniczenia emisji amoniaku w 2030 roku, w wyniku podejmowania działań zawartych w „Kodeksie doradczym dobrej praktyki rolniczej dotyczącej ograniczenia emisji amoniaku". Szacunki emisji wykonano na podstawie metodyki opublikowanej przez Europejską Agencję Środowiska w 2016 roku. Projekcję wykonano dla każdej kategorii źródeł (produkcja zwierzęca, stosowanie mineralnych nawozów azotowych) oraz oszacowano całkowitą emisję amoniaku w 2030 roku, a uzyskane wyniki odnoszono do bazowego roku 2005. Na podstawie przeprowadzonych analiz można stwierdzić, że osiągnięcie celów redukcyjnych wskazanych w dyrektywie NEC będzie trudne. Nie podejmując żadnych działań przyczyniających się do ograniczenia emisji amoniaku w 2030 roku, należy się spodziewać wzrostu całkowitej emisji o 2,7%. Rozpatrując zaś obie kategorie źródeł emisji osobno, należy oczekiwać wzrostu emisji NH_3 o ponad 45% ze stosowania nawozów mineralnych i spadku o 6% z produkcji zwierzęcej. Największy wpływ na ograniczenie całkowitej emisji amoniaku może mieć szybkie przyorywanie nawozów naturalnych (najlepiej w ciągu 4 godzin od aplikacji). Dużym potencjałem charakteryzuje się także działanie polegające na zastępowaniu mocznika saletrą amonową (-12,4) oraz bezrozbryzgowa aplikacja gnojowicy z jednoczesnym przyorywaniem obornika (-11,0%).

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