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REGIONAL DIFFERENTIATION AND POSSIBILITIES OF REDUCING AMMONIA EMISSIONS FROM AGRICULTURE IN POLAND[1]

Key words: ammonia abatement, plant production, animal production, regions

ABSTRACT. The main purpose of this paper was to present ammonia (NH_3) emissions from agriculture, on a regional scale, in 2017, and identify recommendable agricultural practices limiting ammonia emissions. The methodology used to estimate emissions was based on the approach of the National Centre for Emissions Management (KOBiZE). Analyses were based on statistical data of Statistics Poland (GUS), from 2017. The results of the conducted study showed significant spatial differentiation of ammonia emissions from agriculture. The region of Wielkopolska had the highest NH_3 emissions at a level of 34.5 kg NH_3 per ha UAA. Lower ammonia emissions were identified in the following regions: Kujawsko-Pomorskie, Łódzkie, Mazowieckie, Podlaskie and Warmińsko-Mazurskie, between 20.3-24.7 kg NH_3/ha UAA. In total ammonia emissions from agriculture, in Poland, 76.8% constituted emissions from the management of natural fertilisers. The Wielkopolskie and Podlaskie voivodships have a majority share in the emissions of ammonia from animal production – 29.1 and 21.3 kg NH_3/ha UAA, respectively. Whereas, ammonia emissions from plant production in 2017 was 66 Gg, which equals 4.6 kg NH_3/ha UAA. The highest emission of ammonia from plant production was detected in the Kujawsko-Pomorskie, Opolskie and Dolnośląskie voivodships, in regions characterized by the most intensive crop production. Estimated emissions were 6.9, 6.2 and 6.0 kg NH_3/ha UAA, respectively. A reduction of ammonia emissions from agriculture can be obtained through the proper maintenance of livestock and natural fertilisers, and the implementation of low-carbon methods of the application of mineral nitrogen fertilizer.

INTRODUCTION

Ammonia (NH_3) is one of the main anthropogenic atmospheric air pollutants. A major source of ammonia emissions are nitrogen losses generated in agriculture [Petersen et al. 2012]. Nitrogen unused in agricultural production is deposited into the soil or released into surface water, groundwater and the atmosphere. Nitrogen losses cause negative effects, both environmental (acidification and eutrophication of both aquatic and terrestrial ecosystems) and economic (decreased productivity and increased costs of input) [Smil 1999, Krupa 2003]. This process is unavoidable, however, for both environmental and economic aspects, emissions should be limited. Activity undertaken for the environmen-

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

tal protection of rural areas is supposed to be one of the fundamental methods aimed at implementing required changes in the agricultural infrastructure, generating additional economic potential and the mobilisation of the local community.

On 14 December 2016, the European Parliament and the Council accepted Directive 2016/2284 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC [Official Journal of the European Union L 344/1]. The new directive, called the 'NEC Directive' was drafted to adopt EU law to new international agreements concluded under the revised Göteborg Protocol. The intention was to mitigate potential risks to human health and the environment. For each Member State, the Directive specifies the limits for the reduction of ammonia and other air pollutant emissions (SO_2, NO_x, non-methane volatile organic compounds (NMVOCs), particulate matter ($PM_{2,5}$)). Between 2020 and 2029, Poland should reduce ammonia emissions each year by 1%, and after 2030 by 17% in relation to 2005. Furthermore, the Directive obligates Member States to elaborate a national code of best agricultural practices for reducing ammonia emissions in terms of managing the whole life-cycle of nitrogen, improve livestock feed strategies, use low-carbon techniques for manure storage and application, implement low-emission animal housing and reduce emissions from the use of mineral fertilisers. The reduction should be achieved by means of practices listed in the United Nations decision [UNECE 2014].

The purpose of the research was to show regional level differentiation of ammonia emissions from Polish agriculture in 2017 based on current data concerning livestock production and mineral nitrogen fertiliser consumption as well as identify the best agricultural practices limiting ammonia emissions from agriculture in Poland.

MATERIAL AND METHODS

Total ammonia emissions of agricultural origin constitute the sum of emissions from both plant and animal production. Ammonia emissions from plant production were estimated from the total annual consumption of mineral nitrogen fertilisers. Meanwhile, the emissions of ammonia from animal production depend on the size of the livestock population. Statistics Poland data, from 2017, concerning the livestock population (Table 1) and mineral nitrogen fertiliser consumption by voivodships (Table 2), constituted the empirical materials. Considering the lack of data regarding systems of maintaining livestock and the consumption of specific mineral fertiliser forms on a regional level, the authors adopted national indices applied by The National Centre for Emissions Management (KOBiZE) on the share of various animal manure management systems and fertiliser types in total mineral nitrogen fertiliser consumption [KOBiZE 2018]. Ammonia emissions were estimated using methodology applied by KOBiZE, which conducts an inventory and balance of emissions of air pollutants (including ammonia) for the purposes of national and European Union statistics [KOBiZE 2018]. For plant production, ammonia emissions were calculated by multiplying the consumption of different varieties of mineral nitrogen fertilisers by corresponding emission factors. In the calculation of ammonia emissions from animal production, the quantities of nitrogen excreted by each animal category (cattle, pigs, poultry, sheep) and relevant emission factors are used, under guidelines published

Table 1. Size of livestock population by voivodship in 2017

Voivodships	Population size [thous. head]							
	dairy cows	other cattle	sows	other pigs	sheep	laying hens	broilers	other poultry
Dolnośląskie	40	60	31	163	15	2,432	3,463	534
Kujawsko-pomorskie	155	364	122	1,191	7	1,971	9,842	455
Lubelskie	141	221	42	545	18	2,085	4,469	1,200
Lubuskie	30	48	11	137	6	1,255	3,463	1,337
Łódzkie	182	283	74	1,115	14	2,442	9,423	806
Małopolskie	76	86	23	168	86	2,590	2,474	144
Mazowieckie	491	631	67	1,044	6	10,627	27,333	2,092
Opolskie	43	80	36	375	3	851	3,216	98
Podkarpackie	45	36	16	145	19	2,099	3,339	258
Podlaskie	446	547	24	271	26	1,324	11,255	539
Pomorskie	69	141	67	702	16	1,719	4,251	187
Śląskie	44	76	22	220	13	2,300	6,171	178
Świętokrzyskie	54	103	25	208	4	1,378	4,205	293
Warmińsko-mazurskie	207	245	48	471	7	964	3,620	3,795
Wielkopolskie	278	721	272	3,995	23	17,618	17,201	3,295
Zachodniopomorskie	38	54	29	251	6	1,381	9,948	191
Poland	2,341	3,695	908	11,000	269	53,037	123,673	15,403

Source: Statistics Poland data [GUS 2018a]

Table 2. Mineral fertiliser consumption by voivodships in 2017

Voivodships	Consumption [thous. t N]
Dolnośląskie	93.0
Kujawsko-pomorskie	124.3
Lubelskie	123.0
Lubuskie	23.5
Łódzkie	77.9
Małopolskie	26.7
Mazowieckie	130.7
Opolskie	55.0
Podkarpackie	23.6
Podlaskie	63.4
Pomorskie	60.9
Śląskie	25.5
Świętokrzyskie	31.1
Warmińsko-mazurskie	69.7
Wielkopolskie	157.6
Zachodniopomorskie	64.5
Poland	1150.6

Source: Statistics Poland data [GUS 2018b]

by the European Environment Agency [EMEP/EEA 2016]. Precise information concerning adopted emission factors was taken from the studies of Zuzanna Jarosz and Antoni Faber [2019a, 2019b].

RESULTS

Total ammonia emissions from Polish agriculture, in 2017, were 284.4 Gg NH_3, which equals 20.0 kg NH_3 per ha of agricultural land in good culture. The results of the conducted research on ammonia emissions from agriculture showed a significant differentiation between voivodeships (Figure 1). The highest NH_3 emissions were found in the Wielkopolskie Voivodeship, where they amounted to about 34.5 kg NH_3/ha UAA. Slightly lower NH_3 emissions, between 20.3 and 24.7 kg NH_3/ha UAA, were recorded in the following regions: Kujawsko-Pomorskie, Łódzkie, Mazowieckie,

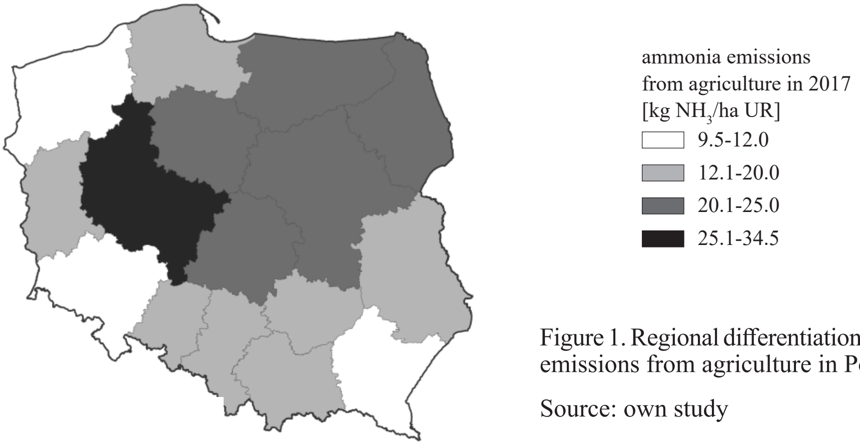

Figure 1. Regional differentiation of ammonia emissions from agriculture in Poland

Source: own study

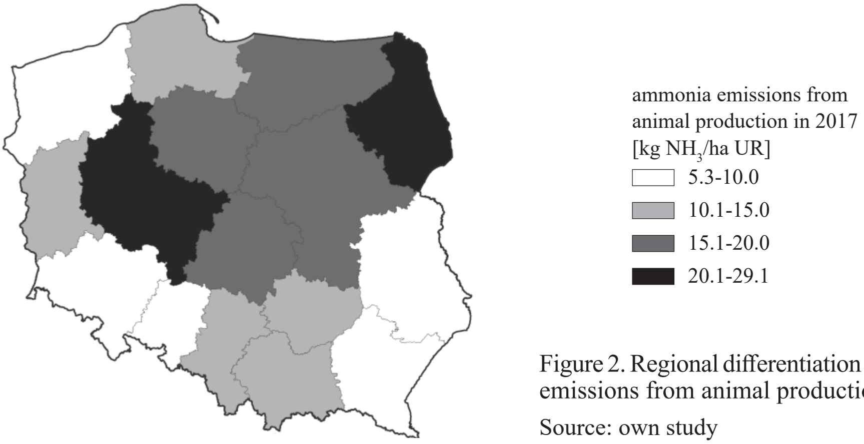

Figure 2. Regional differentiation of ammonia emissions from animal production in 2017

Source: own study

Podlaskie, and Warmińsko-Mazurskie. While the lowest emissions of ammonia from agriculture were found in the Podkarpackie voivodship (9.5 kg NH_3/ha UAA).

Most of ammonia emissions from agriculture, up to 76.8% (218.4 Gg), come from the management system of natural fertilizers.The highest emissions of ammonia from this source were found in the Wielkopolskie and Podlaskie voivodships, and estimated emissions were 29.1 and 21.3 kg NH_3/ha UR, respectively (Figure 2). The level of ammonia emissions from animal production is mainly related to cattle, especially cow production, and equalled 49.3% (of which 29.3% came from cows). In the Podlaskie and Wielkopolskie voivodships, cattle density per hectare of utilised agricultural area is the highest in Poland. Emissions from pig production constituted 28.4% and from poultry 22.3% of total emissions from livestock farming. The Wielkopolskie region has the most numerous pig population.

Ammonia emissions from crop production, in 2017, amounted to 66 Gg NH_3, which accounts for 23.2% of total emissions from agriculture. The highest ammonia emissions of this origin were observed in the following voivodships: Kujawsko-Pomorskie, Opolskie and Dolnośląskie, that is, in regions with the most intensified production (Figure 3).

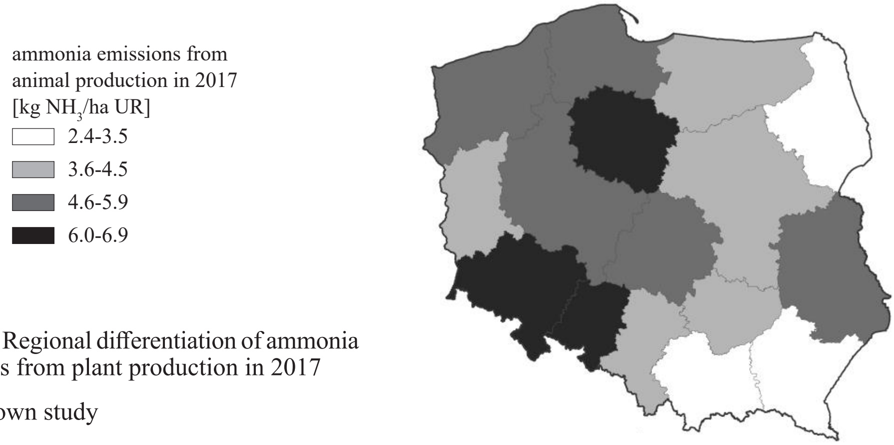

Figure 3. Regional differentiation of ammonia emissions from plant production in 2017

Source: own study

Estimated emissions were 6.9, 6.2 and 6.0 kg NH_3 per ha UAA, respectively. Slightly lower emissions in the range of 4.6-5.3 kg NH_3/ha UAA were identified in the Lubelskie, Łódzkie, Pomorskie, Wielkopolskie, and Zachodniopomorskie voivodships.

The reduction of ammonia emissions may be achieved by implementing practices limiting nitrogen losses. For livestock production, improving feeding and implementing low-carbon systems for livestock farming will contribute to a decrease in ammonia emissions. It is worth noting that those special efforts should be focused on providing better storage conditions and application methods of manure. By minimising exposure to direct contact with the atmosphere of stored natural fertilizers, a decrease in ammonia emissions can be gained, for this reason, covering containers with liquid manure is recommended. This may be done by applying canopies on tanks, movable plastic coatings, natural insulation layers and artificial barrier layers [Petersen et al. 2012, Regueiro et al. 2016].

Weather conditions strongly contribute to ammonia losses from manure storage. Therefore, efforts to reduce ammonia emissions should be mainly focused on minimising landfill and the mechanical compacting of manure.

Recommended practices also include low-emission methods of applying natural fertilizers. The highest nitrogen losses in ammonia form are observed in the first few hours after the application of manure. To prevent this, it is recommended to plough manure as soon as possible. However, the effectiveness of the method decreases gradually, over time [Faber, Jarosz 2018]

Regarding crop production, the use of low-emission mineral nitrogen fertiliser application practices, mainly urea, which has the highest emission factor, contributes to decreasing ammonia emissions. Examples of such dosing methods can be seed drills with coulters for the application of solid fertiliser, or injector for liquid fertiliser deeper into the soil, or the application of urea by injection [Smith et al. 2000, Bittman et al. 2017].

One of the efficient solutions to limiting ammonia emissions is using urea mixed with an inhibitor of urease, resulting in slower urea hydrolysis in soil and ammonia loss inhibition. Among methods limiting emissions of ammonia from mineral nitrogen fertilizers, it is also recommended to use such with a controlled component release, so-called ‘coated’. Nevertheless, this practice increases input costs [Marcinkowski, Kierończyk 2015, MRiRW 2019].

CONCLUSIONS

The conducted study showed a significant spatial differentiation in agricultural ammonia emissions in Poland. Farms specialising in livestock production are mainly responsible for the release of this gas into the environment. The Mazowieckie, Podlaskie and Wielkopolskie voivodships, characterised by the largest number of cattle, have a leading position in ammonia emissions from animal production. Whereas the following voivodships are the main ones in ammonia emissions from plant production: Kujawsko-Pomorskie, Opolskie and Dolnośląskie.

To reduce ammonia emissions, it is necessary to popularise low-emission practices that limit ammonia emissions and, consequently, mitigate the negative environmental impact.

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REGIONALNE ZRÓŻNICOWANIE I MOŻLIWOŚCI REDUKCJI EMISJI AMONIAKU Z ROLNICTWA W POLSCE

Słowa kluczowe: zmniejszenie emisji amoniaku, produkcja roślinna, produkcja zwierzęca, regiony

ABSTRAKT

Celem artykułu jest przedstawienie regionalnego zróżnicowania emisji amoniaku (NH_3) z rolnictwa w 2017 roku oraz wskazanie dobrych praktyk rolniczych, które przyczyniają się do ograniczania emisji tego gazu. Do oszacowania emisji wykorzystano metodykę stosowaną przez Krajowy Ośrodek Bilansowania i Zarządzania Emisjam (KOBiZE). Materiał źródłowy do badań stanowiły dane statystyczne GUS z 2017 roku. Analiza wykazała znaczne przestrzenne zróżnicowanie emisji amoniaku z rolnictwa. Największą emisją NH_3 charakteryzowało się województwo wielkopolskie i wyniosła ona 34,5 kg na ha UR. Mniejszą emisję amoniaku, w zakresie od 20,3 do 24,7 kg NH_3/ha UR stwierdzono w regionach: kujawsko-pomorskim, łódzkim, mazowieckim, podlaskim i warmińsko-mazurskim. W całkowitej emisji amoniaku z rolnictwa w Polsce 76,8% stanowiła emisja z zagospodarowania nawozów naturalnych. Województwa wielkopolskie i podlaskie charakteryzują się największą obsadą bydła na 1 ha UR w Polsce, przez co emisja amoniaku z produkcji zwierzęcej była w tych regionach bardzo duża. Oszacowane emisje wyniosły odpowiednio 29,1 i 21,3 kg NH_3/ha UR, natomiast emisja amoniaku z produkcji roślinnej w 2017 roku wyniosła 66 Gg, tj. 4,6 kg NH_3/ha UR. Największą emisję amoniaku z produkcji roślinnej stwierdzono w województwach: kujawsko-pomorskim, opolskim i dolnośląskim, tj. w rejonach wyróżniających się największą intensywnością produkcji upraw rolnych. Oszacowane emisje wyniosły odpowiednio 6,9, 6,2 i 6,0 kg NH_3 na 1 ha UR. Ograniczenie emisji amoniaku z rolnictwa można osiągnąć przez właściwe utrzymanie zwierząt gospodarskich, odpowiednie gospodarowanie nawozami naturalnymi oraz stosowanie niskoemisyjnych praktyk aplikacji mineralnych nawozów azotowych.

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