Jan Barwicki[*]
Małgorzata Łukaszuk[**]

AMMONIA EMMISSION PROBLEM AND PROPOSAL OF UTILIZATION OF NEW TECHNOLOGY CONCERNING SLURRY ACIDIFICATION TO REDUCE HARMFUL GASES IN ANIMAL BUILDINGS AND DURING SLURRY APPLICATION IN THE FIELD OF OSTROŁĘKA REGION

PROBLEM EMISJI AMONIAKU I PROPOZYCJA WYKORZYSTANIA NOWEJ TECHNOLOGII DOTYCZĄCEJ ZAKWASZANIA GNOJOWICY DLA ZREDUKOWANIA SZKODLIWYCH GAZÓW W BUDYNKACH INWENTARSKICH I PODCZAS ROZLEWANIA NA POLACH W REJONIE OSTROŁĘKI

Introduction

Ostrołęka district is characterized by agricultural production profile and is one of the fastest growing regions in Poland. Agriculture in the region is focused on livestock production and field crops which are subordinated to the production of roughage and concentrates. Production of roughage is based on corn silage prepared in horizontal silos, and hay silage gathered in round bales and protected against loss of nutrients with plastic foil.

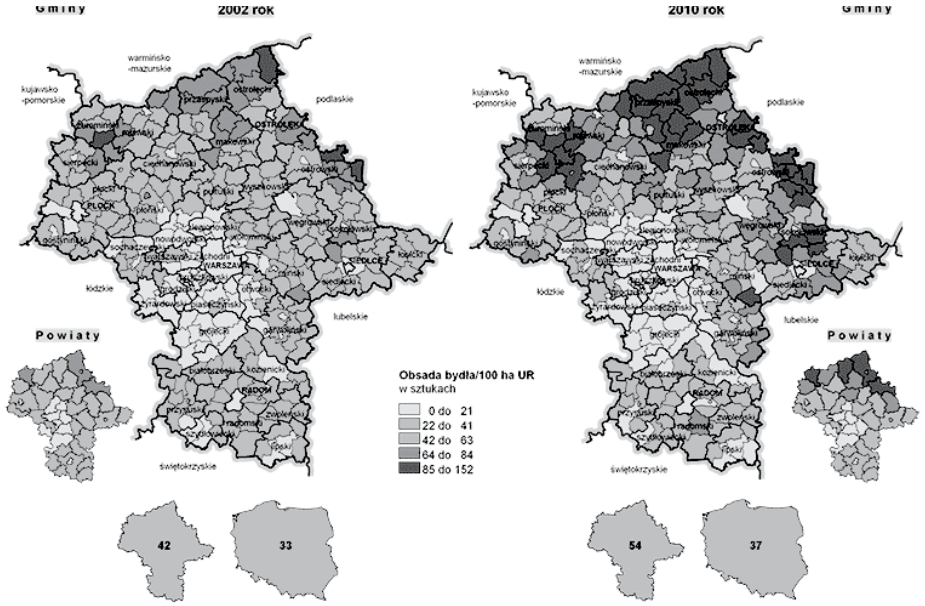
Farmers from the Ostrołęka district usually raise cattle and are at the forefront of milk producers in Poland. According to data collected by ARMA, in 2011–2012 in the district of Ostrołęka, it was recorded as the region with the highest amount of cattle in Poland. It was 140 783 pieces of cattle, including about 80 thousand cows. Concerning the Mazowieckie province, that was counted the highest amount of cows on 100 hectares – about 72.2 pieces.

Farmers from the Ostrołęka district produce: about 450 million liters of milk annually, which is 18 per cent. of milk production in the Mazowieckie province. In these areas there are also the largest milk producers – 4566 of them, who are wholesalers. In this case, the reception of milk by dairies is done directly from the farm.

[*] dr hab., prof. Institute of Technology and Life Sciences, Warsaw Branch, Poland.
[**] mgr inż., Instytut Technologiczno-Przyrodniczy w Falentach.

Figure 1

Changes in the amount of cattle on 100 hectares of agricultural land in the Mazowieckie province and also in Ostrołęka county in the years of 2002–2010



Source: www.mbpr.pl, 2014

The county operates the largest plant for employment, in terms of cattle breeders and milk producers. Assuming that such holdings, when only two people can have a job, they give it to the number of about thousand people, and yet there are farms that have several dozen of cows and even more. In the quota year of 2011–2012 the national milk quota was equal – 9 857 658 127 kg, of which more than 2 billion kg, it means 20.4 per cent., had farmers from Mazowieckie province. On figure 1 it is presented the changes in the amount of cattle on 100 hectares of agricultural land in the province of Mazowieckie including Ostroleka county in the years 2002–2010.

Animal production technologies in the aspect of wastes management

Recently more and more livestock barns, in which animals are kept on slotted floor. Instead of manure as organic fertilizer we gain here liquid manure – a mixture of manure, urine and water. The composition and value of fertilizer depend on the breeding technology, feeding and water delivery system. Cow manure and swine manure are different and they have different effect on environment[1]. Slurry is, usually mixed with some bedding material and some water during management to give a liquid manure with a dry matter content in the range from about 1 to 10%.

Although potassium is available almost immediately after the application of the manure to the soil, with nitrogen, and especially with phosphorus is not so easy. For phosphorus and a large part of nitrogen, they may be available for plants as nutrients, when a process of mineralization occurs, and generally speaking, must become the activity of soil microflora to provide simple mineral compounds, that can be absorbed by the plant. So the activity of the soil microflora depends on the degree of use of manure as fertilizer. Thus, many studies shows that the efficiency of nitrogen supplied in the slurry varies in very wide range from 30 to 70%.

In addition to the mineralization we have to take into account the time – because we want to release the ingredients gradually, along with the course of the growing season. Here, nature favors us, because in the period from April to the end of August the temperatures are highest, which promotes the development of microflora. To the development of microflora was the most intense, you should provide them with more nutrient components. Slurry as organic fertilizer is used mainly before vegetation. It is important that large doses of manure (especially on light soils) is not preceded directly sown plants, as emitted from the manure ammonia can damage and even destroy the root system of rising plants. This assumes that the nutrients and organic matter contained in the slurry should help to increase soil fertility and increase crop yields without the risk of contamination with biogenic compounds of environmental groundwater.

The use of slurry in an uncontrolled way is a threat to the environment. European Union legislation allow for the use of natural fertilizers (solid manure, liquid manure, urine) an amount not exceeded 170 kg of nitrogen (N) in pure ingredient per 1 hectare of agricultural land. Requirements for agricultural construction sites, utilized for solid manure, slurry and urine storage, gives the Act of 10 July 2007 concerning fertilizers and fertilization technology. In case of utilization liquid manure for many years in doses exceeding the nutritional needs of plants, it can reveal symptoms of soil fatigue manifested by reduced yield of plants. It should, however, take into account the slurry in the fertilization of crops on the farm, as part of the supplementary nutrition. Well-applied manure improves soil physicochemical properties.

Development of slurry acidification technology

The international interest for slurry acidification is big and the current draft BREF (Reference Document for Best Available Techniques) has recognised slurry acidification, which will become a compulsory to BAT in all EU member states. There are three main technologies, namely in-house, tank and in-field acidification. Their effects in reducing ammonia emissions from stables, stores and fields are substantial, and in the range of 40 to 64% according official tests, among other the VERA technology verification programme set up in cooperation between Danish, German and Dutch environmental authorities.

Slurry acidification can be explain as equilibrium between the water bound ammonium (NH_4+) and the volatile ammonia (NH_3) is moved towards ammonium

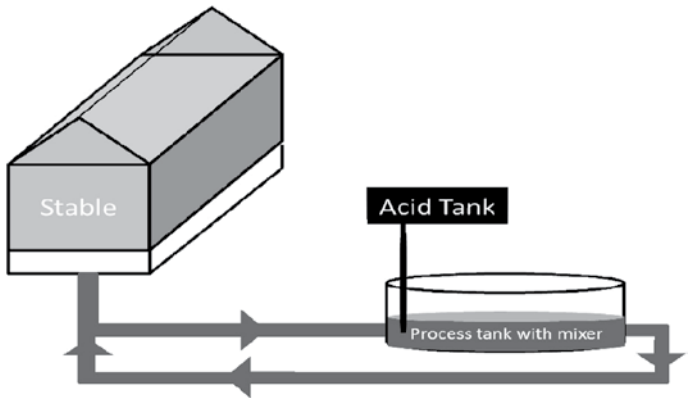
by adding acid to the slurry. Normally, concentrated sulfuric acid is used, and the costs of the acid in many cases outweighed by savings on purchase of S fertiliser. The nitrogen that is captured via avoided ammonia evaporation is turned into savings on purchase of N fertiliser, or in higher crop yields. Slurry acidification also has a considerable climate effect by increasing the carbon sequestration in soil. Reducing the loss of nitrogen from agriculture is key to reducing eutrophication of the Baltic Sea. Most of the airborne eutrophication to the Baltic Sea comes from ammonia emissions, and in the BSR almost all ammonia emissions are from livestock manure. Annual deposition of ammonia nitrogen to the Baltic Sea has been increasing during recent years and was greater in 2012 than in 1995. While emissions are decreasing slightly in some countries, HELCOM Baltic Sea Action Plan calls for a reduction of 118,000 tonnes of nitrogen annually to the Baltic Sea, and the Revised Gothenburg Protocol (2012) calls for ambitious reductions in ammonia emissions from all BSR countries. Slurry acidification also affects solid/liquid slurry separation efficiency positively; DM is higher, N lower and P higher in the solid fraction. A combined treatment should efficiently prevent gaseous emissions, increase fertilizer value of slurry and reduce transport and energy costs.

Three systems of slurry acidification: in house, in storage and in field

Acidification of animal slurry has proved to be an efficient solution to minimize NH_3 emissions in-house, during storage, and after soil application, as well as to increase the fertilizer value of slurry, without negative impacts on other gaseous emissions. Treatment of slurry using acid to reduce pH content in animal buildings is presented on Figure 2.

Figure 2

Treatment of slurry using acid to reduce pH content and harmful state of wastes

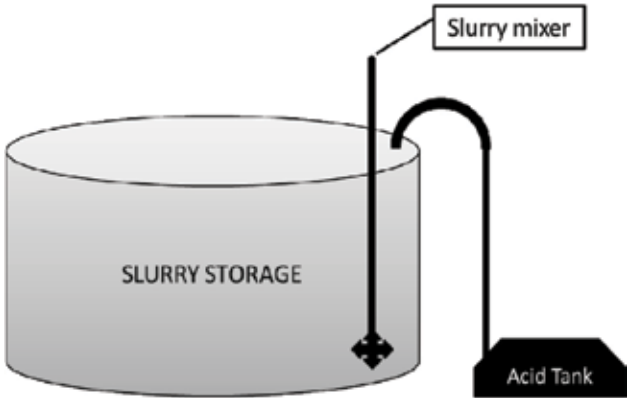


Source: D. Fangueiro 2015

Furthermore, acidification impacts positively on other slurry treatments such as solid liquid separation or composting; upon the use of a non-sulphur containing additive, it may also impact positively on biogas production. Nevertheless, acidification of slurry might induce higher losses by leaching, due to solubilisation of mineral elements.

Acidification of slurry storage tank located on the farm is presented on Figure 3.

Figure 3
Acidification of slurry in storage tank

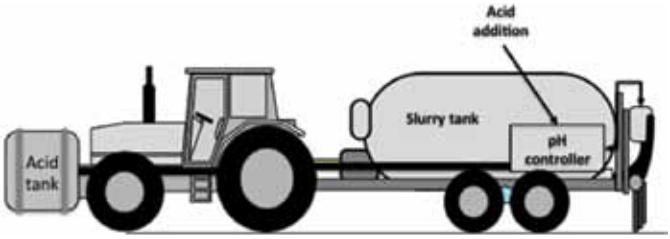


Source: D. Fangueiro 2015

Today, the main limiting factor of this technology is the handling of concentrated acid that has to be performed by specialized workers and, in consequence, increases the cost. Alternatives to concentrated acids already exist but more research is still needed to improve both their technical and economic aspects. Moreover, the lack of specific equipment for the acidification of solid manures and the separated solid fraction narrows the possible fields application and treatment.

The scheme of machinery set for slurry field application using acid tank is presented on Figure 4.

Figure 4
Machinery set for slurry field application using acid tank



Source: D. Fangueiro 2015

More information is needed to have clear evidence that this technology does not induce any pollution swapping. Since slurry acidification is running successfully in Denmark, it is realistic that the technology can be applied in many other countries. However, such dissemination of acidification depends mainly on the country's legislation that will be altered only on a solid scientific basis. On figure 5 it is presented moment of filling the tanker with slurry before going into the field for spreading[2]. In front of the tractor there is acid tank. Acid is pumped to the rear of the tanker, where slurry is mixed with acid in a special tube. This process is provided just before the spreading of the mixture on the field. In the back of a tanker is mounted also pH meter to keep proper value of this parameter. The present review highlights the lack of information relative to the long-term impact of acidified slurry application to soil as well as the need for more research on slurry acidification. Acidification of slurry in pig houses will reduce NH_3 emission from the animal house, the store and after having applied the slurry to land. There are also two other containers, one for spreading additives and another for water, to wash acidified hoses.

Advantages of using acidification technology

Acidification reduces NH_3 emission from pig houses by 70% compared with the standard housing treatment. Little loss was observed from stored slurry, and the NH_3 emission from applied slurry was reduced by 67%. In consequence, a 43% (S.E. 27%) increase in mineral fertilizer equivalent (MFE) was measured in field studies.

The slurry acidification system is approved Best Available Technology (BAT) in Denmark.

Figure 5

Filling the tanker with slurry before going into the field for spreading

Source: Biocover Denmark 2015

On figure 6 it is presented the full set of in field equipment ready to provide in field acidification procedure.

Figure 6

Complete set driving on the field for providing spreading of acidification slurry

Source: Biocover Denmark 2015

Description of processes when adding Sulphur acid to slurry is presented below:

NH_3 (ammonia) + H+ = NH_4+ (ammonium)

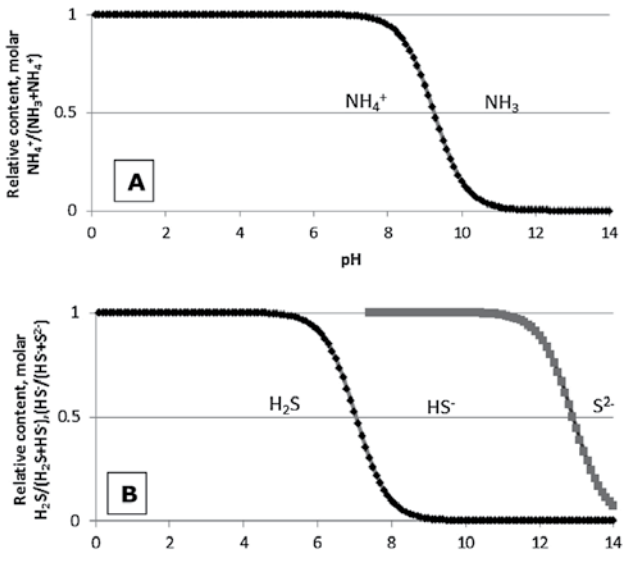
NH_3 = gas –may evaporate NH_4+ = salt – does not evaporate)

H_2SO_4 (Sulphur acid) = Hydrogen – Sulphur-Oxygen = Sustainable

The concept of reducing slurry pH to get lower nitrogen losses to the air relies on the equilibrium between NH_4 and NH_3 what is presented on Figure 7.

Figure 7

Effect of slurry pH on its relative content of NH_4+ (A) and H_2S (B)



Source: D. Fangueiro 2015

Discussion and conclusions

Slurry acidification technology gives many advantages from the point of view soil fertilization and also the limiting of ammonia emission. Of course it requires provide safety procedures to avoid direct contact of farm workers with harmful activity of the acid. But heaving good acidification technology[3], which doesn't allow to have direct contact either in the storage area or in the field with the acid, this job is rather safe while fulfilling the procedures.

Acidification of animal slurry has proved to be an efficient solution to minimize NH_3 emissions in-house[4], during storage, and after soil application, as well as to increase the fertilizer value of slurry, without negative impacts on other gaseous emissions.

Besides that acidification impacts positively on other slurry treatments such as solide liquid separation or composting; upon the use of a non-sulfur containing additive, it may also impact positively on biogas production. Nevertheless, acidification of slurry might induce higher losses by leaching, due to solubilization of mineral elements[5].

The main limiting factor of this technology is the handling of concentrated acid that has to be performed by specialized workers and, in consequence, increases the cost[6]. Alternatives to concentrated acids already exist but more research is still needed to improve both their technical and economic aspects[7]. Moreover, the lack of specific equipment for the acidification of solid manures and the separated solid fraction narrows the possible fields of application of the treatment[8].

It is needed more information to have clear evidence that this technology does not induce any pollution swapping[9]. Since slurry acidification is running successfully in Denmark, it is realistic that the technology can be applied in many other countries[10]. However, such dissemination of acidification depends mainly on the country's legislation that will be altered only with a solid scientific basis[11].

Actual review shows the lack of information relative to the long-term impact of acidified slurry application to soil as well as the need for more research on slurry acidification.

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SUMMARY

Ostrołęka is one of the most developed agriculture region in Poland concerning animal production, but especially cattle production. With high cattle production it is connected well developed proper amount of bulky and concentrate feed. Most of dairy and beef cattle are grown in barn with slotted floor and it is connected with high concentration of slurry what creates ammonia emission problems. The article presents some proposals for development of new technology in this area. Ammonia emission is a major problem associated with animal slurry management, and solutions to overcome this problem and are developed worldwide by farmers and scientists. Quite simple way to minimize ammonia emission from slurry can

be done by decreasing slurry pH by addition of acids or other substances acting in similar way. Using slurry acidification technology in the barn, in the storage or in the field we can avoid many environmental problems concerning ammonia emission. Besides that we can save on overall fertilizers usage on the farm.

Keywords: new technology, slurry acidification technology, ammonia emission, environment protection.

STRESZCZENIE

Ostrołęka należy do jednego z najbardziej rozwiniętych regionów Polski w zakresie produkcji zwierzęcej, ze szczególnym uwzględnieniem produkcji bydła. Wraz z wysoko rozwiniętą produkcją bydła wiąże się dobrze rozwinięta produkcja pasz objętościowych oraz pasz treściwych. Większość krów oraz bydła mięsnego jest hodowanych w budynkach inwentarskich posiadających podłogę szczelinową, co wiąże się z powstaniem wysokiej koncentracji gnojowicy, która stwarza problem emisji amoniaku. Artykuł przedstawia propozycje zastosowania nowej technologii dla rozwiązania tego problemu. Problem ten jest przedmiotem prac prowadzonych w różnych krajach świata przez farmerów i naukowców. Aby w prosty sposób, zminimalizować emisję amoniaku z gnojowicy, można tego dokonać poprzez zmniejszenie jej pH dodając kwasów lub innych substancji działających w podobny sposób. Stosując technologię zakwaszenia gnojowicy w oborze, w zbiorniku do przechowywania gnojowicy lub podczas rozlewania gnojowicy na polu, możemy uniknąć wielu problemów środowiskowych dotyczących emisji amoniaku. Poza tym możemy zaoszczędzić na stosowaniu ogólnej ilości nawozów w gospodarstwie.

Słowa kluczowe: nowa technologia, technologia zakwaszanie gnojowicy, emisja amoniaku, ochrona środowiska.