Bulgarian Journal of Agricultural Science, 25 (Suppl. 1) 2019
Agricultural Academy

Innovative methods for the utilization of emissions from greenhouse and other harmful gases from livestock

Ivan Yanchev*, Kamelia Kancheva, Milena Bozhilova-Sakova

Institute of Animal Science, Kostinbrod, 2232, Bulgaria
**Corresponding author:* ijantcev@mail.bg

Abstract

Yanchev, I., Kancheva, K., Bozhilova-Sakova, M. (2019). Innovative methods for the utilization of emissions from greenhouse and other harmful gases from livestock. *Bulgarian Journal of Agricultural Science*, *25*(Suppl 1), 3–7

The concentration of animals, the farms built close to the settlements and the great environmental requirements necessitate the development of a comprehensive program for environmental protection, assessing the dangers of air, water and soil contamination.

Currently, a number of good technology solutions to reduce emissions exist. Furthermore, there is a number of methods for reducing greenhouse gases, and capturing them using water and reagents is a solution that partially addresses the issue of emissions but does not answer the question of how to use them.

Our studies show that the development of installations for the absorption of these emissions from crop plants in greenhouse production and in different systems of cultivation – soil, using a substrate and hydroponic system in parallel with other methods is a serious possibility for zero emission of harmful gases from livestock buildings with full forced ventilation. Air scrubbers can be constructed not only for ammonia capture but also for both CO_2 and ammonia utilization through pipe systems in greenhouses near the farms.

Keywords: greenhouse emissions; animal husbandry; carbon dioxide; ammonium nitrate; utilization

Introduction

Livestock is responsible for 18% of greenhouse gases measured in CO_2 equivalents according to the FAO Report: http://www.fao.org/newsroom/en/news/2006/1000448/index.html. By comparison, the transport sector drops 13.5% of CO_2 emissions. But livestock and its by-products are responsible for at least 51% of the total greenhouse gas emissions, according to Goodland and Anhang (2009). Aerosols or particles emitted along with carbon dioxide when burning fossil fuels, although harmful to health, also have a cooling effect, which, roughly speaking compensates for the warming effect of CO_2. Therefore, greenhouse gas emissions associated with livestock farming will have an even greater share of global warming in the near future (Fig. 1).

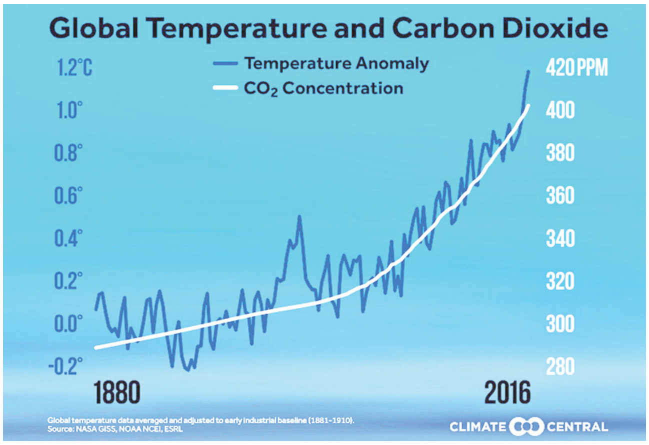

Fig. 1. Global warming dynamics

From studies conducted (Kacergis et al., 1996; Bicudo et al., 2002) it is found that the atmospheric air pollution with ammonia, hydrogen sulphide and other gases in livestock farming is of local importance. With ammonia content in the livestock building 0.02% at 10 m of it in atmospheric air at wind velocity of 0.5-1.0 m/s in the absence of direct sunshine only traces of the toxic gas are present (Büscher et al., 1994). The results from the study about the hydrogen sulphide from livestock buildings and the atmospheric air are similar.

Ammonia is a common by-product of animal waste and is due to the often inefficient conversion of feed nitrogen into the animal product (Kavolelis, 2006). Farm animals and poultry are often fed with high-protein feed containing an excess of nitrogen to ensure that the nutritional needs of the animals are met. Nitrogen which is not metabolized in animal protein (i.e., milk, meat or eggs) is excreted in the urine and stools of farm animals and poultry where the additional antimicrobial action releases ammonia into the air during manure decomposition (Knowlton, 2000).

One of the current issues of air cleanliness in farmed animals is the containment of unpleasantly odorous substances – which are contained in the air leaving the premises (Powers, 2002). Until recently, it was believed that unpleasant smells are only a source of unpleasant sensations in humans. More than 27 gaseous compounds have been identified and are included in the „smell of odors accompanying livestock farms.“ The unpleasant smell of these substances was found to be due to the content of hydrogen sulphide, ammonia, indole, skatole and mercaptans, that the unpleasant sensation exists at concentrations that are permissible for a given atmospheric contaminator (for those contaminants for which there are quantitative test methods and limits for limit values) As a result of laboratory analyses and clinical trials it has been found (Groot et al., 1998, Gay & Knowlton, 2005) that the impact of a "bouquet" of unpleasant smells is ten times more unfavorable than the impact of any of the shed individually. Even in minimal concentrations they cause changes in self-esteem and headaches. Changes in breathing (becomes superficial, which reduces pulmonary ventilation and the intensity of cellular oxidation processes in humans), disturb central nervous system function and reduce productivity in animals as well.

Concentration of livestock has exacerbated the problem of overcoming the adverse effects of unpleasant smells that are released from livestock farms. Using the method of processing survey data from organoleptic surveys, we found that the air in Bulgaria is most polluted by unpleasant odor in livestock buildings, first pigs, and finally broiler and cattle breeding (Krastev et al., 2000). To reduce the amount of unpleasant smells in the air, complex deodorization programs are required. First, they include strict adherence to animal breeding technology and, above all, to the technological requirements for removal and timely transport of fertilizer. Laboratory tests (Patterson & Adrizal, 2005) show that it is possible to reduce the amount of unpleasant smell by 70-89%. Here we need to emphasize the need of a differentiated approach when assessing air contaminants in farmed animals. It is necessary to investigate the quantity of contaminants in the air of livestock buildings not only to evaluate the effectiveness of industrial technology, but also to the health of farm workers. Contaminants should also be assessed in view of their ecological significance in terms of the functioning of neighboring ecosystems.

Current technologies for ammonia capture and carbon fertilization

There are currently a lot of good technology solutions to reduce such emissions (Yann et al., 2014). Washing undesirable pollutants from the air by using water and reagents, for example, is a solution that is specifically targeted to certain compounds. The purpose of air purification through scrubbers (Fig. 2) in farms and manure treatment facilities is to

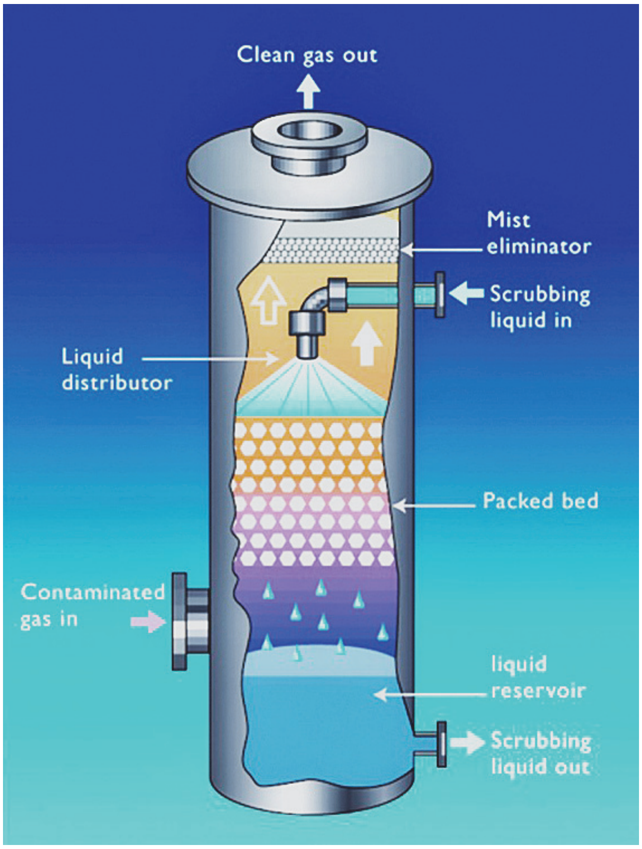

Fig. 2. Scrubber model
Source: https://www.crcleanair.com

reduce dust, ammonia, hydrogen sulfide and volatile organic compounds (VOC) in the exhaust air by water-reactive washing (Lahav et al., 2008, Moore et al., 2013). The level of complexity is higher than dry processes. More than 95% of ammonia and 29% of other odorants are removed by this method. The scrubber is an air tower – a reactor with inert or inorganic filler. The wrapping material is usually of great porosity or free volume. Water is injected into the top and descends downwards, and the contaminated air is introduced either horizontally (crossed) or bottom up (counter current). As a result of intense contact between air and water, pollutants from the gas phase pass into liquid and wash off. Part of running water circulates continuously; another part is discarded and replaced with fresh water.

The transfer of ammonia from the inlet air to the water is regulated by an equilibrium chemical reaction that is influenced by pH and temperature (Rothrock et al., 2013). To improve the efficiency of the processes in the water, an acidic reagent (mainly sulfuric acid), is usually added to the recycled water stream. Thus, the pH is maintained at 3.3-4, for a more complete removal of ammonia. In the water, ammonia is bound as ammonium sulfate. This prevents the release of gaseous ammonia. The acid scrubbing odor removal efficiency results from the decomposition of pollutants in the water phase and the rate of water discharge. Since the solubility in water of the odor-bearing compounds varies, the degree of odor removal varies as well.

Modern modular design scrubbers are available today. Each module is designed for an air flow of approximately 65,000 m^3/h. The air from the ventilation is sucked through the scrubber and purified before leaving the farm. The water is injected through a set of nozzles on the front of the filter reactor at certain intervals. The acid is added with an automatic dosing pump based on the pH of the wash water. With modular systems, the air is sucked through the modules, activating one after the other, in line with the increasing ventilation requirements during the processes. They rotate to ensure uniform distribution of the emission load of all modules. This solution significantly reduces operating costs. The wash water pool should be emptied at regular intervals and the filter cleaned with a pressure cleaner.

This technology solution may be suitable for large farms from a microclimate perspective and partially solves the issue of emissions, but the use of ammonia and other volatile organic gases does not provide a response to their recovery. On the other hand, carbon dioxide is not captured, and it is the biggest problem as a major greenhouse gas. The issue of emissions of methane, which is an even more serious CO_2 pollutant, remains open.

Plant biologists have long known some of the effects of high CO_2 levels on plants, and greenhouse growers have used CO_2 fertilization to increase plant yield. Work on plants from natural ecosystems has lagged behind that on crops but, over the last few years, has produced a large body of information according to a review of Bazzaz (1990). It was highlighted that the major emphases have been on individual physiological traits, but the consequences of these responses for the whole plant, population, and ecosystem are less understood and, in some cases, counter-intuitive. Many plant and ecosystem attributes will directly or indirectly be influenced by elevated CO_2. Ambient CO_2 level in outside air is about 340 ppm by volume. All plants grow well at this level but as CO_2 levels are raised by 1,000 ppm photosynthesis increases proportionately resulting in more sugars and carbohydrates available for plant growth. Any actively growing crop in a tightly clad greenhouse with little or no ventilation can readily reduce the CO_2 level during the day to as low as 200 ppm.

Such innovative installation, built by the Swiss company Climeworks, was set up near Zurich, Switzerland, and absorbs carbon dioxide from the atmosphere by delivering it through a pipeline to a greenhouse where tomatoes, cucumbers and other plants are gas-treated (Fig. 3). The new demonstration facility was officially launched on May 31, 2017 and aims to capture nearly 900 tons of CO_2 per year.

Fig. 3. Carbon dioxide utilization installation in Switzerland
Source: Climeworks, Climate Central

The idea for both carbon dioxide and ammonia usage from livestock utilities

Therefore, in the near future, it is entirely possible to develop installations for reducing emissions of harmful gases as part of the microclimate in the livestock buildings not only in relation to them but also in terms of the health of workers, achieving both welfare and ergonomic effects (Fig 4). They will aim to achieve a local effect of reducing the residual emissions of gases emitted by forced ventilation and significant reductions in emissions of harmful gases.

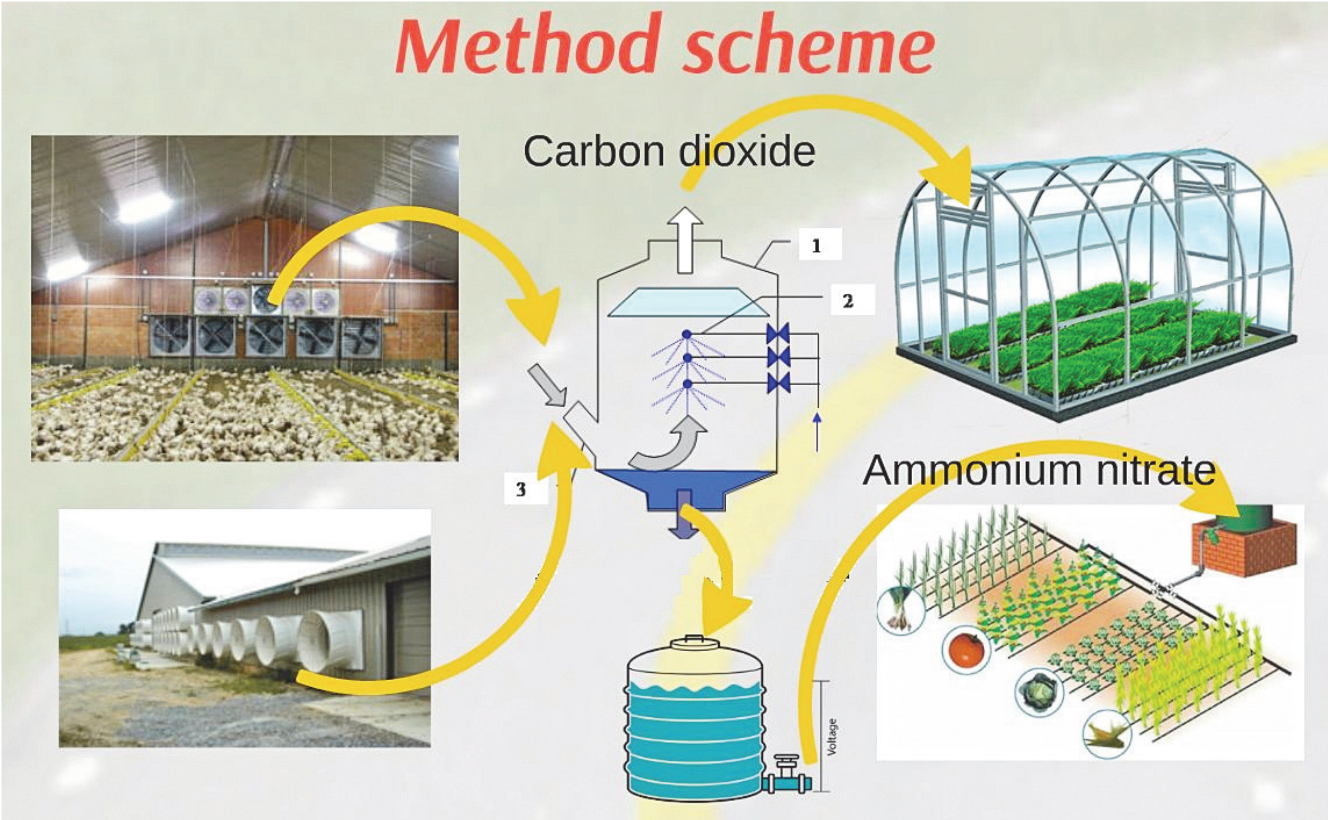

Fig. 4. A possible method for CO_2 and NH_3 utilization from livestock

On the other hand, in such research as a challenge, we determine the use of CO_2 to increase yields of greenhouse cultivated crops. Such investigations will also explore ways to use nitrogen from an aqueous solution of ammonia, respectively. The ammonium fertilization (fertigation) in these plants will seek economic efficiency and applicability in practice.

References

Bazzaz, F. A. (1990). The Response of Natural Ecosystems to the Rising Global CO_2 Levels. *Annu. Rev. Ecol. Syst., 21*, 167-196.

Bicudo, J. R., Schmidt, D. R., Gay, S. W Gates, R. S., Jacobson, L. D., & Hoff., S. J. (2002). Air quality and emissions from livestock and poultry production/waste management systems. National Center for Manure and Animal Waste Management White Papers, North Carolina State University, Raleigh, NC, 57.

Büscher, W., Hartung, E., & Keck, M. (1994). Ammonia emission by different ventilation systems. Animal waste management. Proceedings of the Seventh Technical Consultation on the ESCORENA on Animal Management. Bad Zwischenahn, Germany 17-20 May 1994, pp 45-4916.

Gay, S. W., & Knowlton, K. F. (2005). Ammonia emissions and animal agriculture. Virginia Cooperative Extension, Biological Systems Engineering, Publ. No. 442-110. Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Goodland, R., & Anhang, J. (2009). Livestock and Climate Change. World Watch November/December 2009, 10-19.

Groot Koerkamp, P. W. G., Metz, J. H. M., Uenk, G. H., Phillips, V. R., Holden, M. R., Sneath, W. R., Short, J. L., White, R. P., Hartung, J., & Seedorf, J. (1998). Concentrations and emissions of ammonia in livestock buildings in Northern Europe. *J. Ag. Engr. Res.*, *70*(1), 79-95.

Kacergis, J. B., Jones, R. B., Reeb, C. K., Turner, W. A., Ohman, J. L., Ardman, M. R., & Paigen, B. (1996). Air quality in an animal facility: particulates, ammonia, and volatile organic compounds. *Am. Ind. Hyg. Assoc. J., 57*(7), 634-40.

Kavolelis, B. (2006). Impact of Animal Housing Systems on Ammonia Emission Rates. *Polish J. Environ. Stud.*, *15*(5), 739-745.

Knowlton, K. (2000). Ammonia emissions: the next regulatory hurdle. *The Jersey Journal*, *47*, 56-57.

Krastev, K., Gaidarska, V. & Yanchev, I. (2000). Seasonal changes of fat content of milk of black-and-white cows. *Bulg. J. Agric. Sci*., *6*, 697-700.

Lahav, O., Mor, T., Heber, A. J., Molchanov, Sh., Ramirez,J. C., Li, C., & Broday, D. M. (2008). A New Approach for Minimizing Ammonia Emissions from Poultry Houses. *Water Air Soil Pollut*., *191*(1), 183-197.

Moore, P., Maguire, R., Tech, V., Reiter, M., Ogejo, J., Burns, R., Li, H., Miles, D., & Buser, M. (2013). Development of an Acid Scrubber for Reducing Ammonia Emissions from Animal Rearing Facilities Animal Manure Management, Small and Backyard Flocks November 13, 2013.

Patterson, P. H. & Adrizal (2005). Management strategies to reduce air emissions: Emphasis—Dust and ammonia. *Journal of Applied Poultry Research, 14*(3), 638-650.

Powers, W. (2002). Emerging air quality issues and the impact on animal agriculture: Management and nutritional strategies. In Proceedings 49th Annual Maryland Nutrition Conference for Feed Manufacturers, Timonium, Md.

Rothrock M. J., Szögi, A. A., & Vanotti, M. B. (2013). Recovery of ammonia from poultry litter using flat gas permeable membranes. *Waste Management*, *33*, 1531–1538.

Yann M., Neveux, T., Makhloufi, K., Roizard, D., Kanniche, M., & Favre, E. (2014). Development of a CO_2 Capture Process Based on Ammonia Solvent and a Dedicated Composite Hollow Fibre Membrane Contactor. *Energy Procedia*, *63*, 651-658.