Air scrubbing techniques for the reduction of gaseous emissions from livestock farms. Actual knowledge in the Netherlands and possibilities for implementation on Spanish farms

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Resumen

En los Países Bajos, el uso de biofiltros o filtros ácidos para la eliminación de la carga de amoniaco en el aire extraído de las granjas, es una técnica común para la mitigación de las emisiones de amoniaco. Actualmente, una nueva generación de filtros de aire conocidos como “scrubbers multifuncionales” está siendo desarrollada. Este sistema reduce no sólo la emisión de amoniaco, sino también de partículas y olores. Este tipo de sistemas de limpieza de aire no son frecuentes en granjas españolas. El estudio, por tanto, de estas técnicas así como su posible implantación a las granjas españolas resulta interesante desde el punto de la mitigación y reducción de las emisiones de gases y contaminantes, con el fin tanto de cumplir con los compromisos internacionales adquiridos, como de reducir las posibles molestias causadas a la sociedad.

Abstract

In The Netherlands, packed-bed biotrickling filters and acid scrubbers for removal of ammonia from exhaust air of animal houses are off-the-shelf techniques for ammonia removal. At the moment a new generation of so-called "multi-pollutant scrubbers" is being developed and tested that also removes odour and particulate matter from the air. Air cleaning systems are unusual in Spanish farms. The study of these techniques and their adaptation to Spanish farms, can be an interesting issue in order to achieve the national gas emission reduction commitments, and also to reduce social nuisances.

Palabras Clave (Keywords)

Limpieza de aire, emisiones gaseosas, ganadería, scrubber.

Air cleaning, gas emissions, livestock, scrubber.

Introduction

Intensive poultry and pig operations are main contributors to ammonia, odour and particulate matter emissions in agriculture. Furthermore, odour emissions from animal housing is being increasingly considered a nuisance, due to the approximation in the space of farming areas and rural residential developments. During the last years, international commitments (v.g. Kyoto Protocol, European Ceilings Directive 2000/81 CE) are binding the countries to reduce total emissions of atmospheric pollutants. In Spain, projections for ammonia emissions are

not successful (IIASA, 2007), which means that several work must be done in this field. The use of techniques to reduce emissions has achieved, then, a key role in livestock farming.

Many reduction techniques have been developed until the moment. They have been deeply reviewed by the European Commission in the BREF document (European Commission, 2003). From these techniques, the ones which are focused on airborne emissions reduction can be classified in two main groups: preventive techniques and palliative techniques. In the first group techniques related to animal feeding, housing conditions or manure management can be included. Those techniques are aimed to reduce the emission from the origin, trying to avoid favourable conditions for them. In the second group, techniques such as additives and air cleaning systems are contained.

The development of these reduction techniques has been traditionally carried out in Central and Northern European countries and, therefore, their performance hasn't been tested yet in Spanish conditions. The aim of this paper is to review the actual knowledge about air scrubbers in The Netherlands and to evaluate the adaptation of this technique to Spanish farms.

Scrubbers principle

An air scrubber is a reactor filled with an inert or inorganic packing material. This material is intermittently sprayed with water to keep it wet. The exhaust air of the farm is driven through the scrubber. This process results in a contact between air and water, and enables a mass transfer from gas to liquid phase. A fraction of the trickling water is continuously recirculated, while another fraction is discharged and replaced by fresh water. The main scheme of a scrubber is shown in Figure 1.

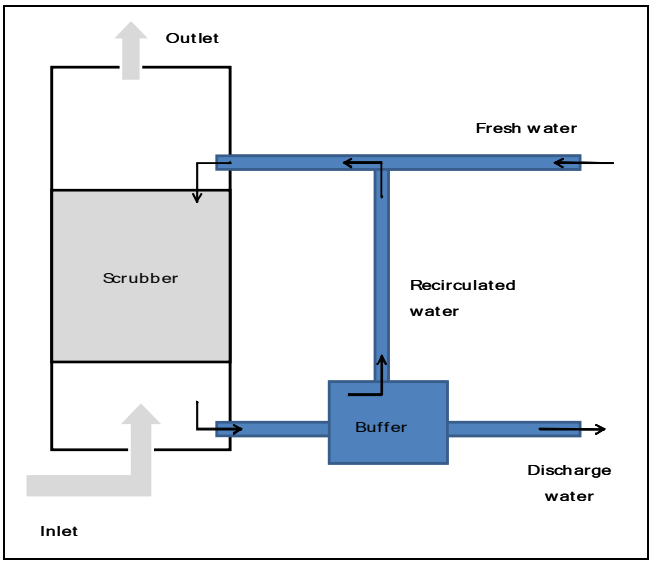

Figure 1. Schema of a single stage scrubber. Modified from (Melse and Ogink, 2005)

Regarding to their operation principle, we can classify the scrubbers in three main groups: chemical scrubbers, biofilters or biotrickling scrubbers and multi-pollutant scrubbers.

- *Chemical scrubbers* are based on the capture of ammonia in an acid solution that is being recirculated over the packed material. An ammonium salt is formed then, that will be discharged with a determined frequency. Usually sulphuric acid is applied and pH is kept between 2 and pH 4.
- *Biofilters or Biotrickling scrubbers*. In this case, no acid is added to the recirculation water, allowing there the formation of bacterial biofilm in the packing material. These bacteria degrade the water soluble components of the air that have been trapped in the water. Due to this bacterial activity, ammonia is converted into nitrites and nitrates. Nitrogen concentrations in the water are kept below inhibiting levels by regular discharge of the recirculation liquid.
- *Multi-pollutant scrubbers*. Consist in a combination of both previous systems. To improve the odour removal capacity of biofilters, a previous air clean is carried out. Then, dry matter and ammonia are eliminated by a water scrubber and chemical scrubber respectively, before the air comes into the biofilter.

Current Dutch experiences

At present, about 900 farms are equipped with air scrubbers in The Netherlands (Melse *et al*, 2008). Figure 2 shows a scrubber installed in a piggery.

Figure 2. Chemical scrubber installed in a fattening pigs farm in The Netherlands

Regarding to their performance, Melse and Ogink (2005) reported an average ammonia removal efficiency of 96% in ammonia and 31% in odour emissions for acid scrubbers. For biotrickling scrubbers an average reduction of 70% for ammonia and 40% for odour emissions was found. Currently a research program is being carried out in The Netherlands to introduce multi-pollutant scrubbers. These multi-pollutant scrubbers are usually multi-stage scrubbing systems (Arends *et al.*, 2008). First data about multi-pollutant scrubbers suggest an average reduction of ammonia emissions of about 83%, 40% for odour emissions and particulate matter (Melse *et al*, 2008).

Adaptation to Spanish conditions

The application of these techniques in Spain can be a useful way to reduce pollutant emissions from livestock farming. But there are several constraints that have to be considered and studied:

Water consumption. Air scrubbing techniques are based in the pollutant exchange between gas and liquid phases. In this process, some water is retained in the air which can be traduced in high water consumption rates. In some Spanish areas water availability is very limited and therefore water costs can be high. Some improvements must be done in this sense.

Climate conditions. Warmer climates are typical from Mediterranean regions. In Spain, it can be also combined with a wide range of humidity rates. The performance of these systems has to be tested in extremely warm and dry climates which could cause an increase of water consumption, or even in warm and very humid conditions, in which phase exchange could be difficult.

Structural issues. Scrubbers produce an extra pressure drop for the fans. This is a problem that can be considered when designing new buildings and also new climate control systems. But many problems can arise when trying to implement this system in an existing farm. Structural problems have to be considering as well, since scrubbers are usually installed in farms with just one channel for the outflow which is not usual in Spain (Figure 3).

Figure 3. Detail of fans distribution in a Spanish laying hens farm

Cost. Obviously, the cost is always a crucial issue. The operation cost of a scrubber has been estimated for Dutch conditions, being about up to14 €/year per pig place (Melse and Ogingk, 2005). This is a very high cost for Spanish farmers. In addition, this value should be estimated considering country-specific conditions or even local conditions.

Conclusions

Air scrubbing is a reliable technique for the reduction of gas emissions. It has become as an off-the-self technique for livestock air treatment in central Europe countries like The Netherlands. It also can be a reliable technique for Spanish farms, but many constraints are found when trying to use it in typical Spanish farms and climatic conditions. Therefore, it seems obvious that further on-site research must be carried out, mainly on the adaptation possibilities, and also to find new designs or improve existing ones.

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