NH_3 recovery from digestate using gas-permeable membranes: Effect of wastewater pH

B. Molinuevo-Salces, B. Riaño*, D. Hernández*, I. González-García*, M. B. Vanotti**, M. C. García-González**

**Agricultural Technological Institute of Castilla y Léon. Ctra. Burgos, km. 119. 47071 Valladolid (Spain) (E-mail: ita-molsalbe@itacyl.es)*

*** United States Department of Agriculture, Agricultural Research Service, Coastal Plains Soil, Water and Plant Research Center, 2611 W. Lucas St., Florence, SC, 29501, USA*

Introduction

Figure 1: *On-site* pilot plant.

Agriculture is the largest source of **NH_3** emissions in Europe, with a contribution of a 91% of the total NH_3 emissions in 2016. This gas has harmful effects on the environment and the human health and the current regulation on air quality states a reduction commitment for NH_3 annual emissions for each European country. **Gas-permeable membranes** have been proved as an efficient technology to capture NH_3, reducing emissions while recycling nutrients in the form of a valuable ammonium salt. The EU project **Ammonia Trapping** is aimed at reducing NH_3 emissions in livestock wastes facilities by using gas permeable membranes in *on-site* pilot plants.

Objectives :

1. recovering NH_3 from digestate by a pilot plant, installed at the biogas facility
2. evaluating the effect of wastewater pH on the NH_3 recovery rate.

Material and methods

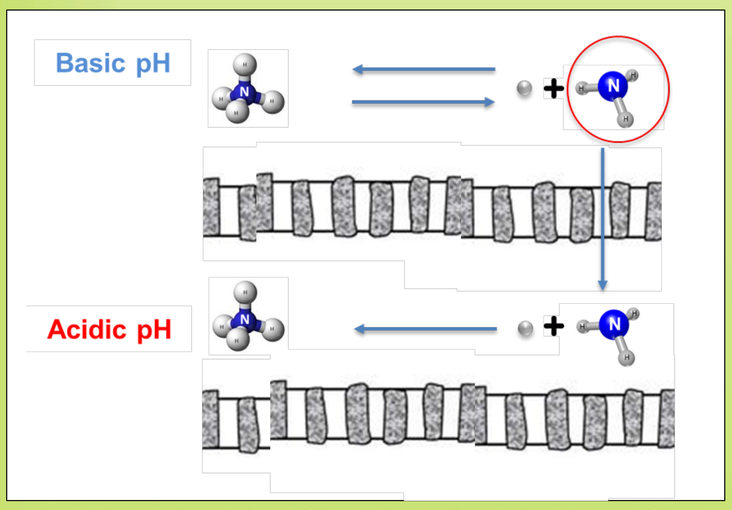

Figure 2: Principle of NH_3 capture by the gas-permeable membranes

The pilot plant was placed inside a mobile container, located in the biogas plant (Fig. 1). The pilot plant consisted of a **NH_3 separation reactor tank** of 5.85 m^3 (working volume 5 m^3) that contained 16 **membrane modules** in vertical configuration. The total membrane surface was 8.85 m^2. The membrane was tubular and made of e-PTFE with an outer diameter of 5.2 mm. A solution of 1N H_2SO_4 was contained in a 0.25 m^3 **NH_3 concentration tank** (working volume 0.15 m^3). This acidic solution was used as a trapping solution and it was continuously recirculated through the membrane. A PLC controlled the pilot plant. The digestate was mixed in cycles of 20 seconds on and 10 seconds off. The pH in the trapping solution was maintained below 2 by adding concentrated H_2SO_4 whenever the pH of the trapping solution increased up to 2. Aeration in on /off cycles of 180 seconds each was provided (Fig. 3).

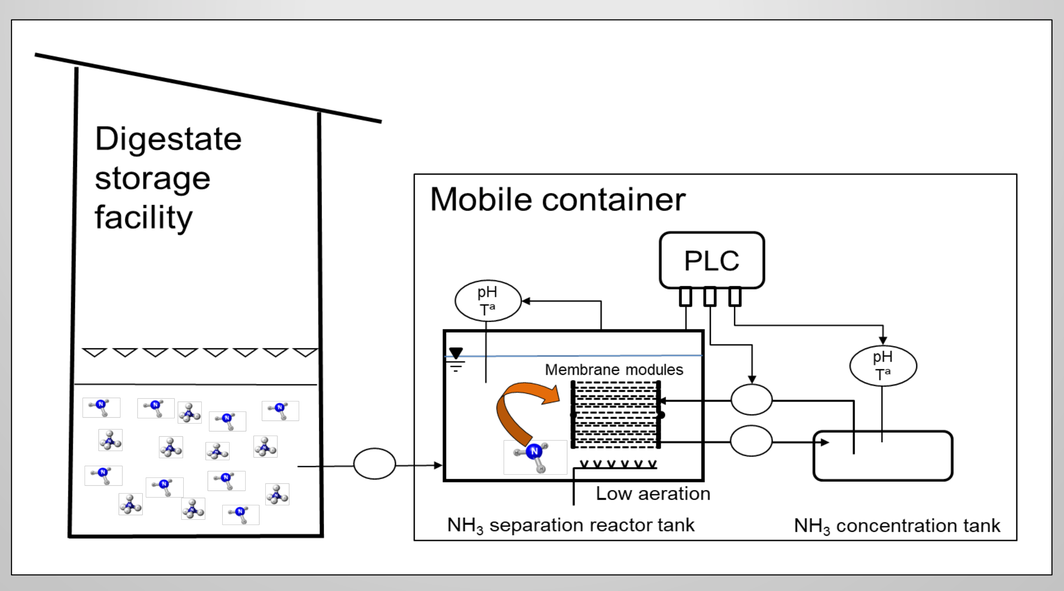

Figure 3: Scheme of the pilot plant.

Results & Discussion

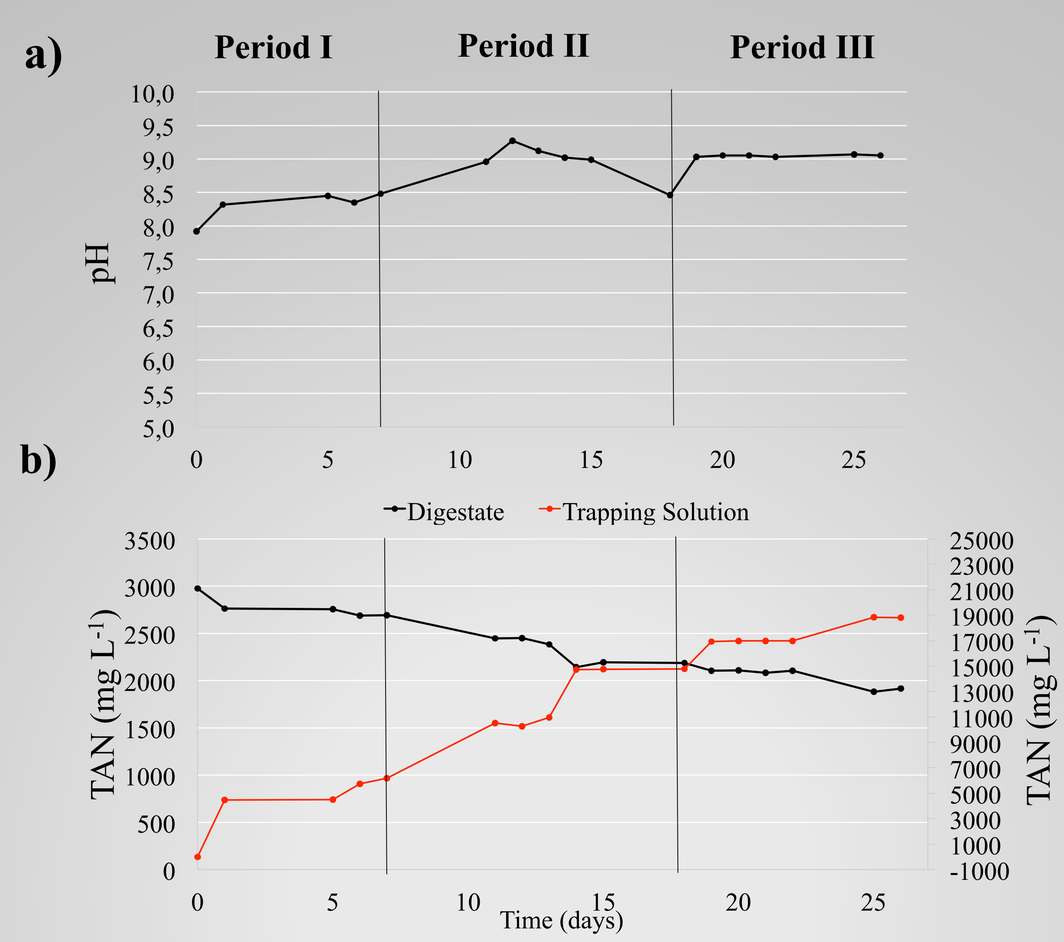

Figure 4: pH in the digestate (a) and TAN removal and recovery (b) during periods I, II and III.

Increasing pH values were tested, corresponding to pH values of 8.3 ± 0.2 (period I), 8.9 ± 0.3 (period II) and 9.0 ± 0.0 (period III) (Fig. 2a). The same digestate was used during the whole study. Initial pH in the digestate was 7.92 and it increased to 8.48 at the end of period I. The same trend was observed for period II, reaching pH values up to 9.3. However, pH was maintained in 9 during period III (Fig. 2a).

Thirty seven percent of the initial TAN in the digestate was removed during the whole experimental time (Fig. 2b). TAN removal was greater during period II, with a pH of 8.9 ± 0.3, with a 19% out of 37%. Opposite to previous assays in batch mode (García-González and Vanotti, 2015; Dube et al., 2016), TAN removal increased with time, following a linear trend. As an average, 52% of the removed TAN was recovered in the trapping solution. The trapping solution reached a final TAN concentration of 18.8 g TAN L^{-1}, meaning that TAN was approx. 6 times concentrated than in the digestate. The TAN recovery rate was around 14 g m^{-2} membrane day^{-1} for the three pH-values tested.

Conclusions

Nitrogen recovery from digestate by gas-permeable membranes was greatly affected by pH in the anaerobic digestate. Although high pH values enhance NH_3 removal, a high proportion of this NH_3 is lost to the atmosphere by stripping. In order to avoid NH3 stripping, it is recommended to increase the ratio of membrane surface per volume unit of digestate.

This study was funded by project Life+ AMMONIA TRAPPING (LIFE15-ENV/ES/000284) "Development of membrane devices to reduce ammonia emissions generated by manure in poultry and pig farms".