A novel bioscrubber for the treatment of high loads of ammonia from polluted gas

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Keywords: ammonia, bioscrubber, gaswaste, high loads
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Abstract

At present, the management of industrial waste is one of the major problems of society development. A wide range of pollutants are emitted from industrial facilities such as odorous compounds, VOC's, NH_3 or H_2S. Ammonia (NH_3) is a colourless, strongly odorous, toxic, reactive and corrosive gas that is a by-product of the biological degradation of urea, proteins and amino acids found in the organic fraction of municipal solid wastes. Traditionally, physical-chemical process has been used for the abatement of gaseous pollutants such as adsorption with activated carbon, wet-scrubbing, incineration, and air stripping. However, high operational cost and secondary pollutant streams are the main disadvantages of this kind of treatments(Dorado et al., 2015). For this reason, in the few past decades, the interest in biological treatments have been increasing for the treatment of a wide range of pollutants. Low operational cost and reduction or elimination of secondary pollutants emissions are the main advantages of this kind of treatment.

Biological air treatment processes have been demonstrated to be useful in commercial and industrial applications, offering cost-effective solutions for the treatment of large airstream volumes containing low-to-moderate levels of pollutants (Yasuda et al., 2009). Typical bioreactors configurations are classified in biofilter (BF), biotrickling filter (BTF) and bioscrubber (BS) depending on their set up and performance. In a BF, the biomass grows on a filter material (organic or inorganic), the polluted gas is degraded when passes through the packed bed. Water is periodically sprinkled on the top of the biofilter in order to achieve the proper moisture conditions for the biomass development. When high concentrations of pollutant are treated an overall reduction performance might be observed due to clogging of the packed bed (Barbusinski et al.).

In biotrickling filters, similarly than in BF, the biomass grows on a packed bed and the contaminated gas passes through the packed bed where is degraded to less harmful compounds by the biomass. However, in a BTF the water phase is constantly recirculated (Kawase et al., 2014), thus, the excess of biomass could be easily removed from the packed bed, minimizing channelling and clogging problems. Due to that, the liquid phase is constantly recirculated the pH and the nutrient supply can be easily controlled. On the other hand, bioscrubber seems to be the best option when high hydrophilic compounds are treated (like ammonia). A bioscrubber is formed with one absorption column and a tank (bioreactor). In the column the polluted gas is mixed with the liquid phase, thus the pollutant is transferred from the gas phase to the liquid phase. The liquid phase is constantly recirculated between the column and the tank, where the pollutant absorbed in the column is degraded by the suspended biomass in the bioreactor (Barbusinski et al., 2017).

When high loads are treated in the traditional biofilters or biotrickling filters the clogging of the packed bed can occur (Barbusinski et al., 2017). To overcome this, suspended biomass reactors can be used instead of packed bed bioreactors. In this sense, the bioscrubber is a two steps reactor. In the first step, the pollutant is absorbed into a scrubbing solution (normally water or mineral media) in an absorption tower. The liquid phase containing the dissolved pollutant is subsequently drawn off and transferred to a continuous stirred tank that contains the active biomass. The second step takes place into the tank and the pollutant is degraded by the microorganisms suspended within. Water is constantly recirculated through the tank and the absorption column (Nisola et al., 2009). Due to its configuration, the bioscrubber offers better options to control parameters such as pH, O2 supply and nutrients addition.

The aim of this work is to evaluate the performance of a bioscrubber for the treatment of high loads of NH3 (>50 ppmv), under different operational conditions, such as such as EBRT, inlet ammonia concentration, pH and liquid flow. In order to increase the performance of the bioscrubber system a novel MBBR (Moving Bed Biofilm Reactor) configuration was used. In a MBBR the biomass grows on a carry material which is constantly moved inside the bioreactor. The main advantage of this system is the robustness and the possibility to treat high polluted streams (Barwal and Chaudhary, 2014). During the last decades these systems has been proving their capability and robustness for the treatment of highly polluted wastewater. However, their utility for the treatment of waste gases still unexplored. Due to their configuration, bioscrubber seems to be the best available technique to try to use the MBBR for the gas treatment.

Acknowledgements

This work was supported by Secretaria d'Universitats i Recerca del Departament d'Empresa i Coneixement de la Generalitat de Catalunya. The authors would like to acknowledge financial support from Centro para el Desarollo Tecnológico Industrial (CDTI) and ECOTEC-Ecología Técnica, S.A.

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