DEVELOPMENT OF BIOLOGICAL SYSTEMS FOR THE AEROBIC REMOVAL OF N_2O

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N_2O emissions represent nowadays a significant fraction of the total Green House Gas (GHG) emissions in the European Union with a yearly atmospheric concentration increase of 0.3% (Fig. 1). N_2O is not only one of the main GHGs (its global warming potential is 298 times higher than that of CO_2), but it is also one of the major causes of ozone depletion.

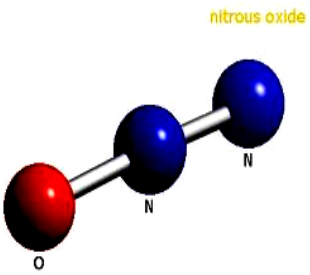

Figure 1. Molecular structure of nitrous oxide (N_2O).

N_2O is mainly emitted from waste treatment activities (10 million tons of CO_2-eq), nitric and adipic acid production (27 million tons of CO_2-eq) and livestock farming (21 million tones CO_2-eq). Therefore, the **minimization and abatement of N_2O emissions** is mandatory due to their high environmental impact and the enforcement of stricter environmental regulations.

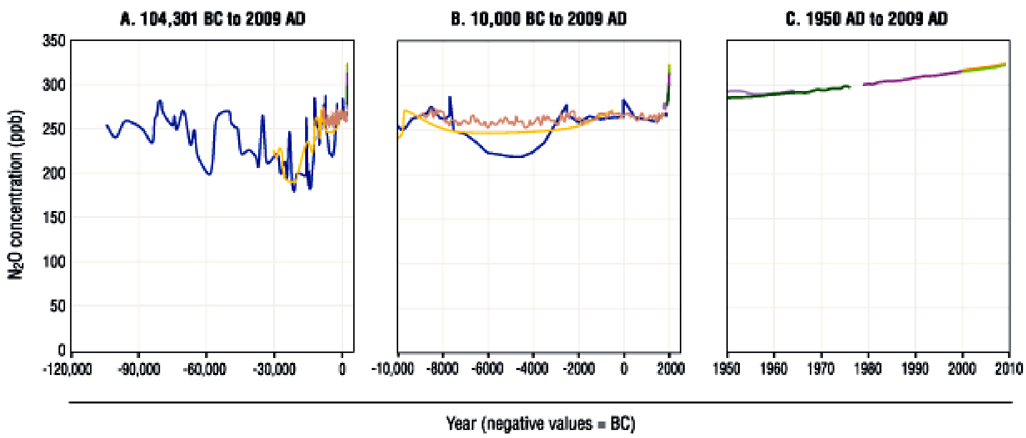

Figure 1. Global atmospheric concentrations of N_2O over geological time and in recent years (www.epa.gov).

Conventional NO_x technologies such as selective catalytic reduction or selective non-catalytic reduction present prohibitive operating costs and large environmental impacts. In this context, biotechnologies (biofilters, biotrickling filters, bioscrubbers) can become, if properly tailored, a low-cost and environmentally friendly alternative to physical/chemical methods for the abatement of N_2O. Biotechnologies, which are based on the biocatalytic action of specialized bacteria, microalgae or fungi, have been consistently proven as robust and efficient abatement methods for the treatment of industrial volatile organic compounds (VOCs), exhibiting lower operating costs and environmental impacts than their physical/chemical counterparts (Estrada et al., 2011). However, the application of biological technologies for N_2O removal is still scarce.

The biodegradation process is mainly limited by the poor mass transfer of N_2O from the gas to the aqueous phase containing the microorganisms (due to the low N_2O solubility). There is also a lack of knowledge on the biodegradation process of N_2O under aerobic conditions and on the biodegradation kinetics at the trace level pollutant concentrations typically present in the aqueous phase (μg/L).

This project aims at developing and evaluating different advanced biotechnologies based on a direct N_2O transfer gas-microorganisms (in contrast with the classical gas-water-cell transport pathway), capable of overcoming mass transfer limitations, optimizing the aerobic denitrification process by selection and characterization of hydrophobic microbial communities with high affinity for N_2O.

More specifically, the work will be focused on the design, start-up, operation and optimization of the operating conditions of different bioreactor configurations for N_2O treatment:

1. Gas-phase membrane bioreactors combine the selective extraction of the target gaseous pollutants and O_2 from the contaminated air emission with their biodegradation by a microbial community attached on the other side of the membrane in contact with a discrete aqueous phase containing the nutrients required for microbial growth. The hydrophobic membrane acts as an interphase between the air emission and the microbial community, increasing the local concentration gradients and therefore the overall mass transfer rates.

Figure 2. Laboratory scale pilot plant

2. Two-phase partitioning bioreactors are characterized by the addition of an immiscible, non-volatile organic phase with a high affinity for the target gaseous pollutant, offering a new and more efficient pathway for N_2O transport.

3. Fungal biofilters support both a high K_la and mass transport driving force as a result of the large surface area of the fungal aerial mycelia and their high hydrophobicity (one order of magnitude larger than that of bacteria and higher at low moisture contents). In addition, this project is expected to provide new insights on the kinetics of N_2O biodegradation at trace level concentrations.

More information available at:

http://etuva.blogspot.com.es/

Relevant publications

López JC, Quijano G, Souza TSO, Estrada JM, Lebrero R, Muñoz R (in press) Biotechnologies for greenhouse gases (CH_4, N_2O, CO_2) abatement: state-of-the-art and challenges. Applied Microbiology and Biotechnology.

Estrada, J., Kraakman, B., Muñoz, R., Lebrero, R., 2011. A comparative analysis of odour treatment technologies in wastewater treatment plants. Environmental Science and Technology 45, 1100-1106.