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Review

Recent advancements in the mitigation of obnoxious nitrogenous gases

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ABSTRACT

Nitrogenous gaseous emissions commonly have an obnoxious odor associated with it, which when discharged into the environment results in serious environmental problems and health hazards. Several strategies for mitigation of nitrogenous odorants have been reported which include physical, chemical and biological methods. Biological treatments are widely employed because of their efficiency even at low concentration, where physical and chemical methods are not effective. Most commonly used biological treatment methods are biofiltration, biotrickling filters and membrane bioreactors with innovative reactor design, mixing pattern, and air sparging, for example FEBR, ALR, etc. These treatment methods require a critical assessment for the mitigation of obnoxious nitrogen emissions, especially in the context of environmental protection. This review offers a critical evaluation of treatment methods for the mitigation of nitrogenous odorous compound with a key emphasis on biological treatment systems. Also, various mathematical modelling techniques required for optimized operation of biotreatment systems has been discussed.

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Nomenclature

P	Pressure drop	X_{act}	biomass density
ε	Bed porosity	μ	growth constant
C_{air}	Concentration of the compounds in the air	Y	total biomass yield
t	time	K_s	Monod's constant
Z	axial dimension	k	death rate constant (it is assumed that the death rate is proportional to biomass present)
V	interstitial velocity	β	inactive biomass constant (presuming that persistent fraction of failing biomass is conserved as inactive material)
V_A	approach velocity		
θ	porosity of the medium	r_A	Ammonium oxidation
D_{flow}	Dispersion coefficient	r_N	Nitrite oxidation
C_{bf}	Compounds concentration present in the biofilm	S_b, NH_4	Biofilm concentration of ammonium
J_{bf}	flux of compounds	S_b, NO_2	Biofilm concentration of nitrite
x	coordinate perpendicular to the biofilm	S_b, O_2	Biofilm concentration of oxygen
D_w	Molecular diffusion constant of the compounds	X_A	Ammonia-oxidizing biomass (g COD m^{-3})

1. Introduction

Nitrogenous gaseous emissions from various industrial plants often comprise of an obnoxious odorous compounds. Nitrogenous odorous compounds occur naturally (through decomposition of organic wastes) and are also emitted by different industries and agricultural processing units. These are mainly wastewater treatment plants, livestock farming units, landfills, fish meal manufacturing units, petrochemical industries, paper industries, and food processing industries (Ndegwa et al., 2008; Ho et al., 2008; Lebrero et al., 2013). Nitrogenous gases include compounds like ammonia, trimethylamine (TMA), dimethylamine (DMA), diethylamine (DEA), triethylamine (TEA), pyridine, etc. These nitrogenous odors have received immense consideration due to their obnoxious odor, corrosivity, and toxicity (Stuetz, and Frechen, 2001). These N gases have been affecting the environment by contributing to the greenhouse effect, acid rain and eutrophication (Estrada et al., 2011; Xie et al., 2013; Groenestijn and Kraakman, 2005). They also have a vast impact on human health such in the form of abnormal neurogenic symptoms (Townsend and Howarth., 2010), altered rRNA synthesis (Helali et al., 2011) and teratogenic effects (Gandu et al., 2013). The cycle of obnoxious nitrogen gases originates from various sources and participates in the different acid base reactions such as nucleation, oxidation, dissolution and deposition in the environment. This has been schematically represented in Fig. 1.

With an increase in industrialization, government agencies of different countries are now forced to lay down stringent environmental legislations to ensure non-toxic breathable air. Hence, such industries are now bound to adopt a reliable treatment method to guarantee that these gases are released into the environment are as per the threshold limit/regulatory norms. Prevalent methods used for the removal of odorous nitrogenous gases such as catalytic oxidation (Yu et al., 2015), absorption (Kennes and Veiga., 2013; Guo et al., 2015) and biological filtration (Brown et al., 2013; Lebrero et al., 2014; Brienza and Chiron, 2017). Biological technologies due to their cost effectiveness are sustainable and preferred for pollution abatement in the present scenario.

This review attempts to present different physical, chemical and biological treatment processes for the nitrogenous compounds along with its bottlenecks and remedies. Specific attention is given to biotreatment technologies that include reactor configuration, packing media, microbial consortium, etc. Some innovative developments in the operational and configurational parameters in biological treatment technology are further deliberated to offer a single explanation for the treatment of odorous nitrogenous gases. Also, fundamentals regarding reactor modelling are elucidated concerning the treatment of nitrogenous gases (Ho et al., 2008).