Abatement of odour from tobacco process emissions by condensation, scrubbing and biofiltration

By

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Declaration

I hereby declare that this submission is my own work and that, to the best of my knowledge and behalf, it contains no material previously published or written by another person nor material which to substantial extent, has been accepted for the award of any other academic qualification of a university or other institute of higher learning except where an acknowledgement is made in the text.

Amila Jeevan Wijayawardhana

July, 2008

To my father (Jagath) and my mother (Sunethra),
for all that I am.

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Abstract

A study was conducted to evaluate the removal efficiency of NH_3 and Hydrogen Sulfide emitted from tobacco process emissions by biofiltration. The experiments were based on testing the removal efficiency of the contaminants on four types of packing material, namely: coconut fiber/tobacco compost, peat/wood chips, garden waste compost/wood chips and inert plastic media/garden waste compost. Results indicate that maximum removal efficiencies of ammonia and hydrogen sulfide (100% and 100% respectively) can be achieved for coconut fiber/tobacco compost mixture while similar removal efficiencies was obtained by peat/wood chips mixture. The maximum elimination capacities for ammonia for the respective packing materials were 5.59, 7.74, 4.58 and 1.98 gm^3h^{-1}. Hydrogen sulfide maximum elimination capacities for the same packing materials were 6.99, 9.91, 6.04 and 2.96 gm^3h^{-1}. The study was conducted as a preliminary evaluation for selecting the most suitable packing material relevant for application in an industrial scale biofilter for the treatment of the same waste gas stream.

An industrial biofilter of 23 m^3 in volume, packed with a coconut fiber filter medium inoculated with tobacco compost (20% by weight) was operated for a period of 45 days. The biofilter was supplied with a humidified gas stream from tobacco processing with main components being ammonia and hydrogen sulfide. The flow rate of the gas stream was varied from 1160 m^3h^{-1} to 2100 m^3h^{-1}. Results indicated that hydrogen sulfide and ammonia were effectively removed 100% and 95% under an empty bed retention time (EBRT) of 36s and 100% and 90% under an EBRT of 20s respectively. Maximum elimination capacities of 5.9 $gm^{-3}h^{-1}$ and 27.6 $gm^{-3}h^{-1}$ were reached for an inlet loading of 1.8 $gm^{-3}h^{-1}$ and 3.8 $gm^{-3}h^{-1}$ for ammonia and hydrogen sulfide respectively.

An industrial scale odour abatement system was designed and constructed, consisting of three units namely: condenser, scrubber and biofilter, the latter acting as the major unit of the system. The gas passes initially through a shell and tube heat exchanger giving moderate pollutant removal (7% ammonia). The gas stream is then directed to a packed column scrubber where average removal of 85% ammonia and greater than 19% hydrogen sulfide was achieved. The two layer biofilter unit (24 m^3 in total volume) was packed only in a single layer (11.65 m^3 in volume) with a mixture of coconut fiber and tobacco compost (90/10 (w/w)) and was used to polish off remaining hydrogen sulfide completely while more than 95% of ammonia removal overall was achieved, resulting in a non odourous gas stream emitting to the atmosphere at ambient temperature. To our knowledge, this is the first waste gas treatment system employing the tri-combination of condensation, scrubbing and biofiltration for the removal of odourous contaminants from tobacco waste gas.

Nomenclature

BTEX	Benzene, Toluene, Ethyl Benzene, Xylene
C_{in}	Inlet Concentration (gm^{-3})
C_{out}	Outlet Concentration (gm^{-3})
C/N	Carbon to Nitrogen ratio
CFU g^{-1}	Colony Forming Units per gram
DEA	Di ethyl amine
DMA	Di methyl amine
DMDS	Di methyl di sulfide
DMTS	Di methyl tri sulfide
EBRT	Empty Bed Residence Time
EC	Elimination Capacity ($gm^{-3}h^{-1}$)
GC-MS	Gas chromatography-Mass spectrometry
H_2S	Hydrogen Sulfide
K_s	Half saturation constant
K_2HPO_4	Potassium di hydrogen ortho phosphate
$MgSO_4.7H_2O$	Anhydrous magnesium sulfate
NH_3	Ammonia
NH_4Cl	Ammonium chloride
$(NH_4)_2 SO_4$	Ammonium sulfate
OU	Odour units (m^3h^{-1})
PVA	Poly Vinyl Alcohol
ppb	parts per billion
ppm	parts per million
Q	Gas flow rate (m^3h^{-1})
RE	Removal efficiency (%)
TEA	Tri ethyl amine
TMA	Tri methyl amine
TOC	Total Organic Carbon
TRS	Total reduced sulfer
V	Biofilter media volume (m^3)

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