Biofiltration of Ammonia in Closed Systems

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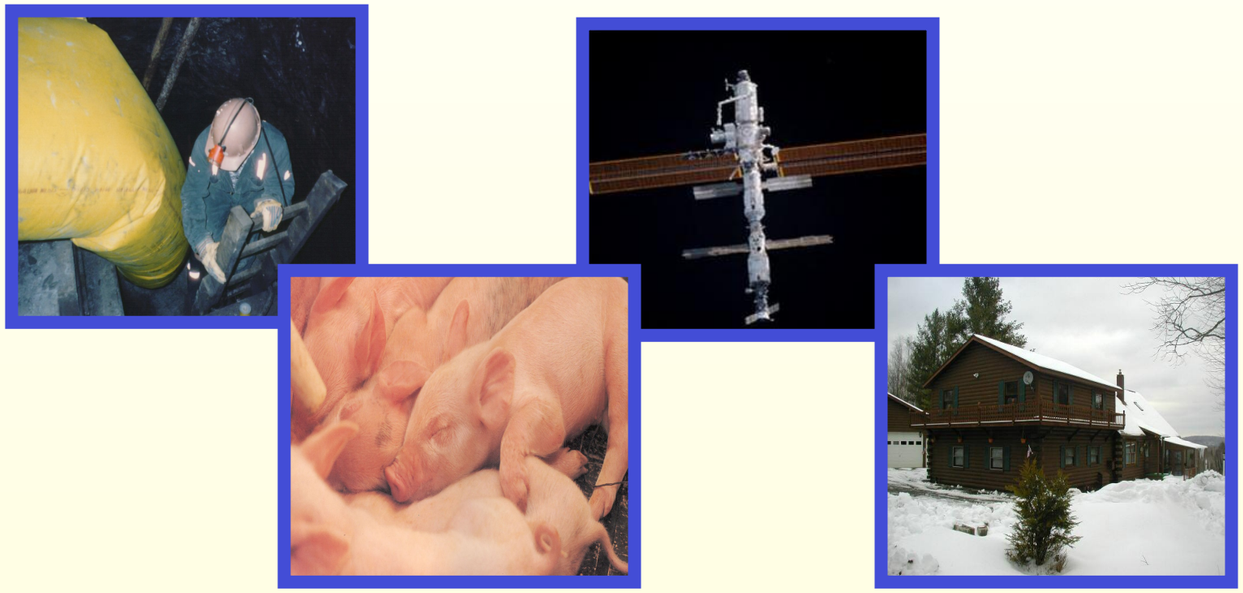


Ammonia (NH_3)

Inorganic molecule

Nuisance gas

Odor threshold = 0.043 to 53 ppm

Short-term exposure

(<500 ppm) nasal/pharyngeal irritation

(>500 ppm) irritation to the eyes, skin, nose, mouth, throat and lungs

Ammonia (NH_3)

Chronic exposure

(40ppm) headaches, nausea and reduced appetite

Acute exposures

(>2500ppm) life threatening

Agriculture

Livestock housing and mushroom farms

Residential dwellings

Americans spend 90% of their time indoors

Industrial settings

NH_3 is one of the most extensively used industrial chemicals in North America[1]

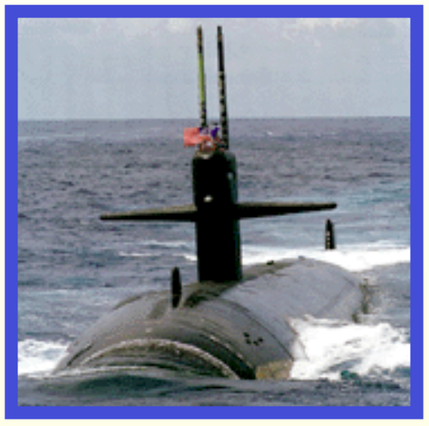
[1] WHO,1990. Ammonia Health and Safety Guide. WHO Health and Safety Guide No. 37. World Health Organization, Geneva. Pg.30.

Mining

Shaft blasting using nitrogen-based explosives produces NH_3

Advanced life support systems (ALSS)

SMAC[1] values = 30 ppm/hour
= 20 ppm/day
= 10 ppm/week to 6 months



1Perry, J.L., NASA technical publication 1998-207978.

Biofiltration vs. ventilation

Ventilation

- Not always possible
- Exchange of contaminated indoor air with "fresh" outdoor air
- Outdoor air must be conditioned (heat & humidity)
- Not energy efficient

Biofiltration is proposed as an alternative

Biofiltration of ammonia

Microbial degradation of ammonia

$$H^+ + NH_{3(gas)} \rightleftharpoons NH_4^+{}_{(aq)}$$

↓ *Nitrosomonas*

$$2NH_4^+ + 3O_2 \rightleftharpoons 2NO_2^- + 4H^+$$

↓ *Nitrobacter*

$$2NO_2^- + O_2 \rightleftharpoons 2NO_3^-$$

Plants and ammonia

Phytoremediation

The use of plants to degrade, extract, contain or immobilize contaminates from soil, water or air

Plant-microbe interactions

Symbiotically enhance microbial communities

Mosses

Shade tolerant

Prefer moist conditions

High surface area (1.6m^2g^{-1})

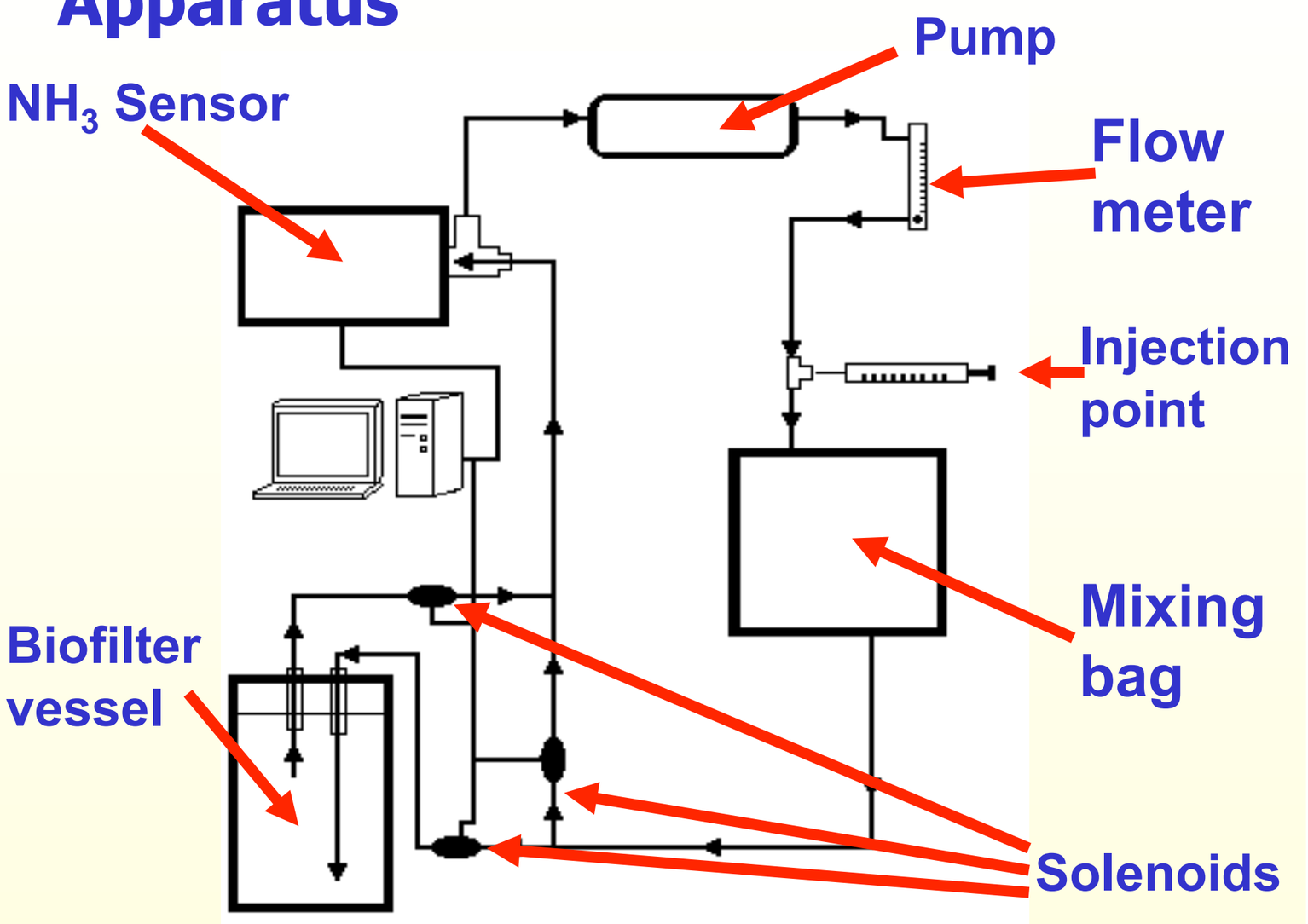
Porous

Bioregenerative

Study objective

Evaluation of plant based biofilters exposed to NH_3 contaminated air streams (< 50 ppmv)

Apparatus


Pump
NH_3 Sensor
Flow meter
Injection point
Mixing bag
Biofilter vessel
Solenoids

Variables and calculations

Measurements

Influent (C_i) & effluent (C_e) NH_3
Biomass (fresh and dry)

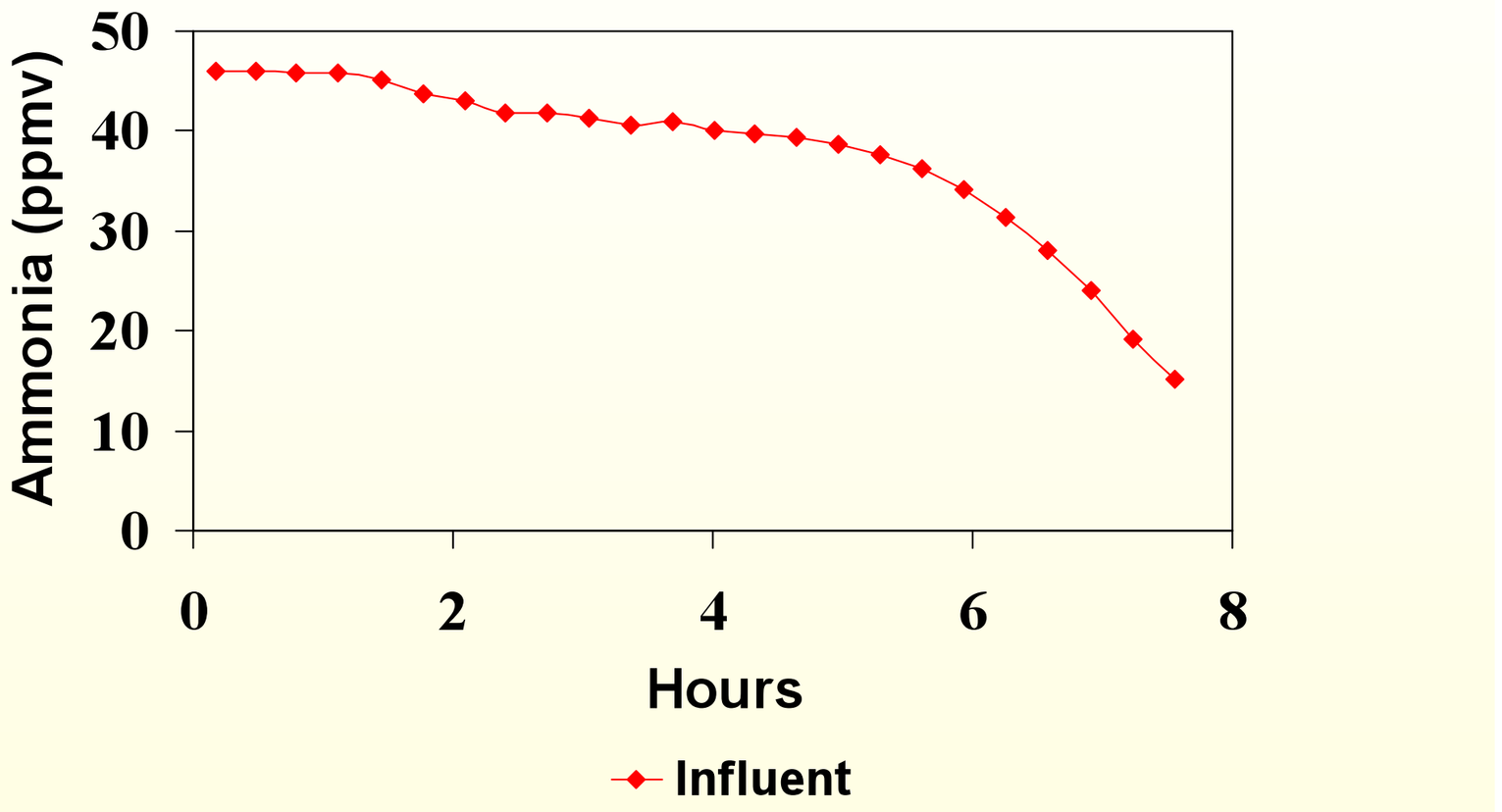
Removal efficiency (RE)

$$RE\ \% = (1 - ((C_i - C_e)C_i^{-1}))*100\%$$

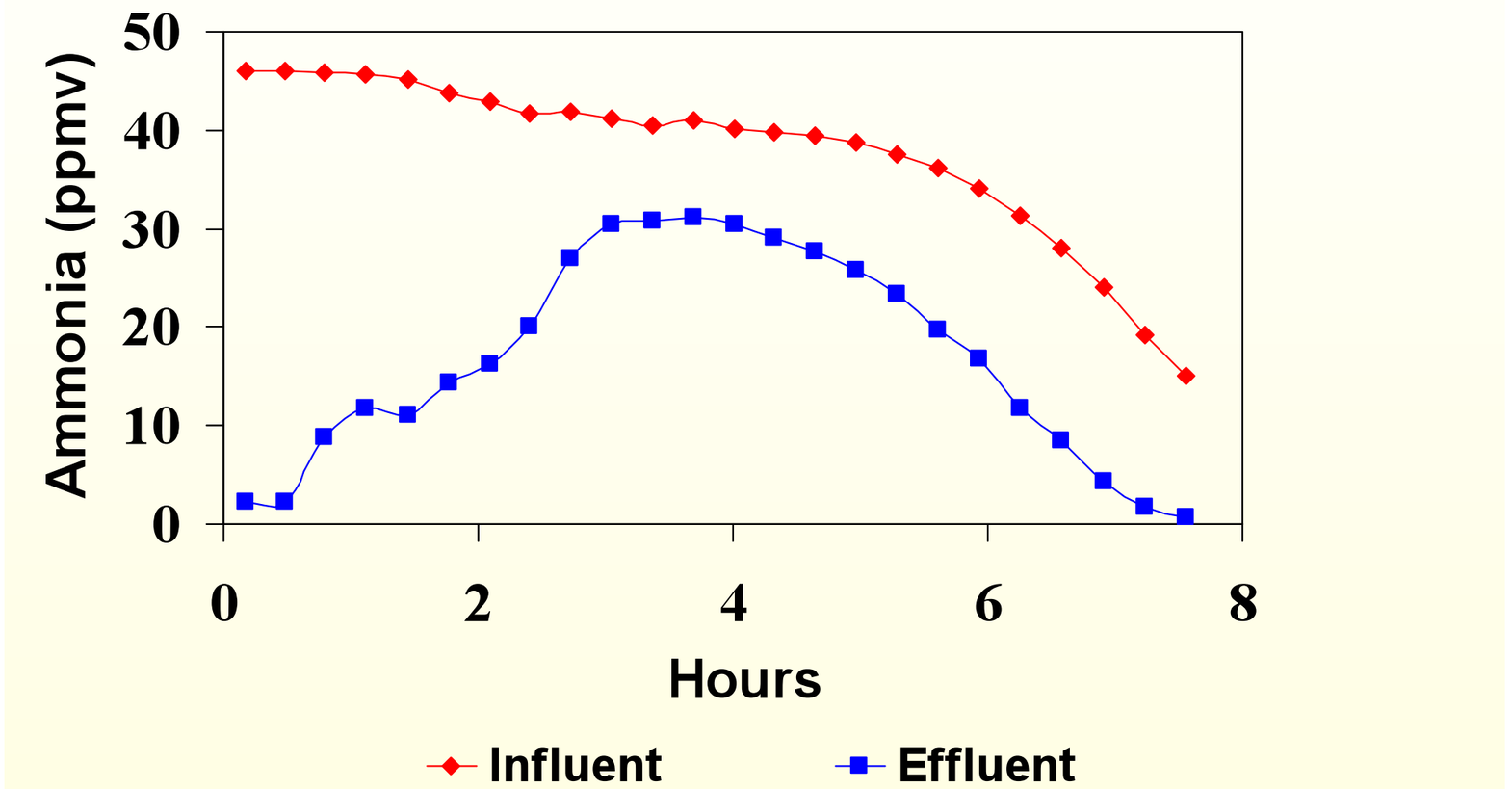
Elimination capacity (EC)

$$EC = \mu g_{NH_3} g^{-1}_{biofilter} h^{-1}$$

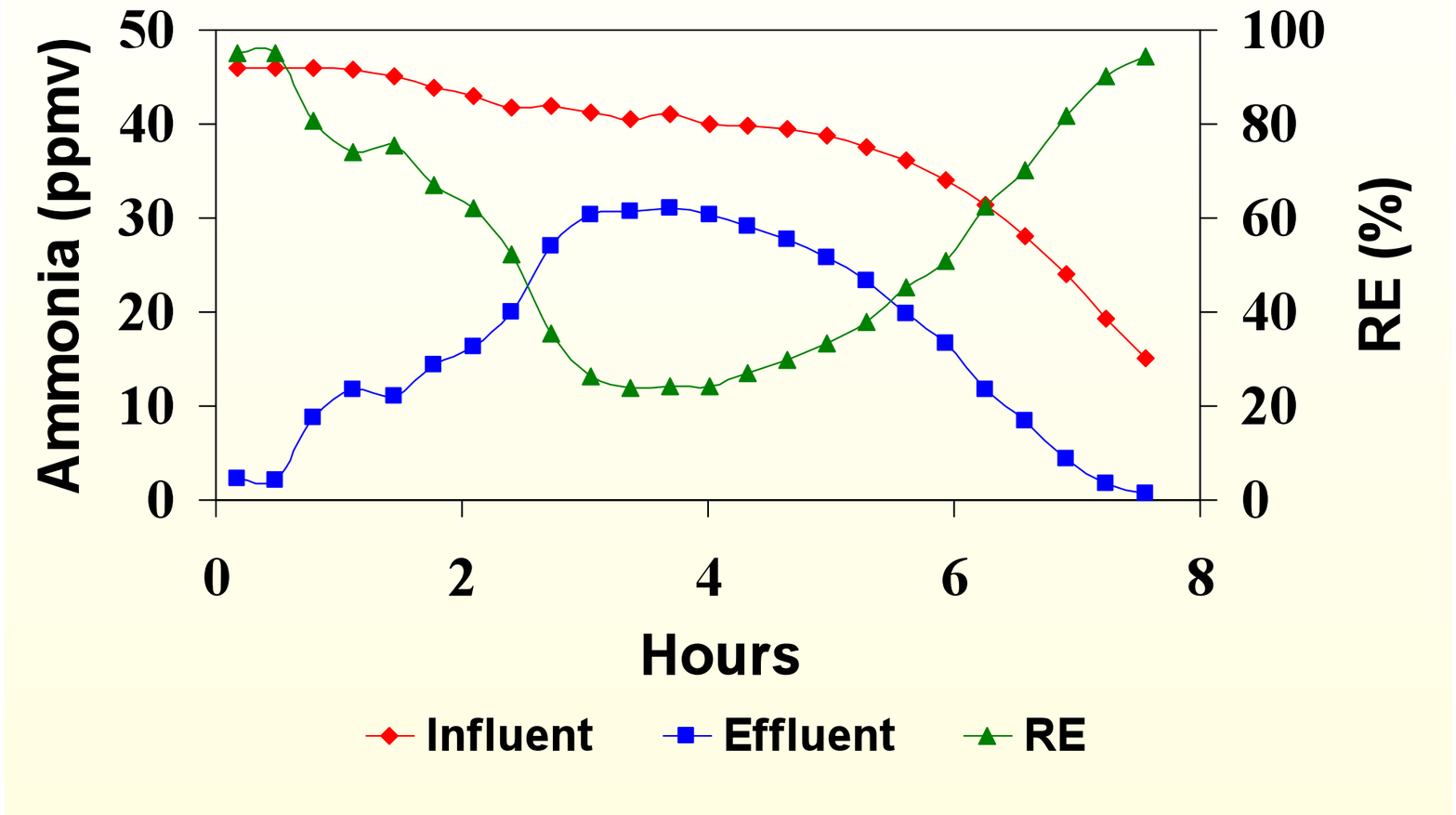
Biofiltration



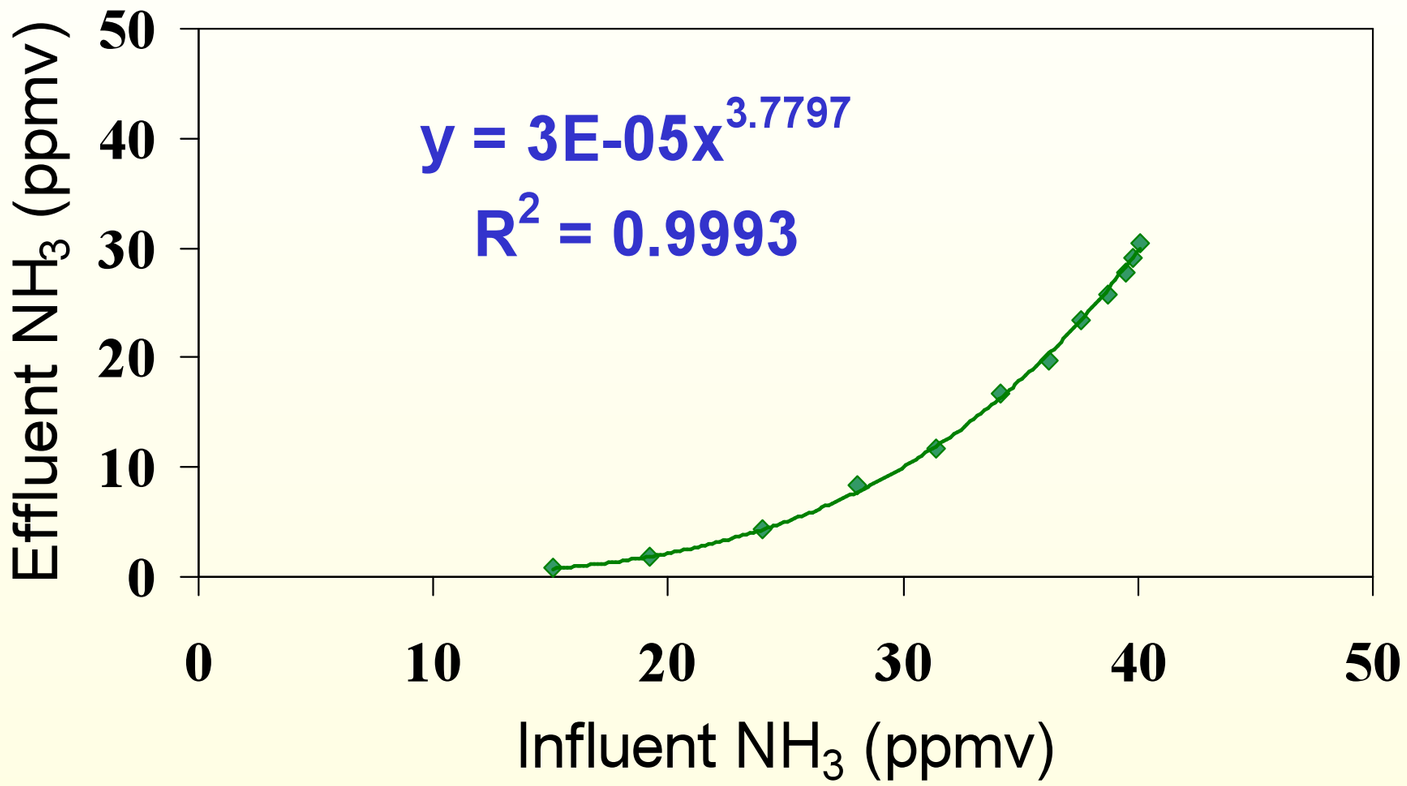
Biofiltration



Biofiltration



Influent/effluent NH_3 post saturation



EC and RE (C_i = 25ppmv)

Elimination capacity ($\mu g_{NH_3} g^{-1}_{biofilter} h^{-1}$)	16.7	±3.21
Removal efficiency (%)	55.37	±9.31

Conclusion

- NH_3 accumulations can be problematic in closed environments
- Moss-based biofilters removed NH_3 from air streams contaminated with 50 ppmv or less
- NH_3 adsorption to the biofilter was seen for the first several hours
- Future work – long term studies of biofilters are needed in NH_3 contaminated settings

Acknowledgements

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Air - According to Nature's Intentions
Air Quality solutions

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CESRF

Clean air

Pollutants degraded