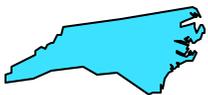


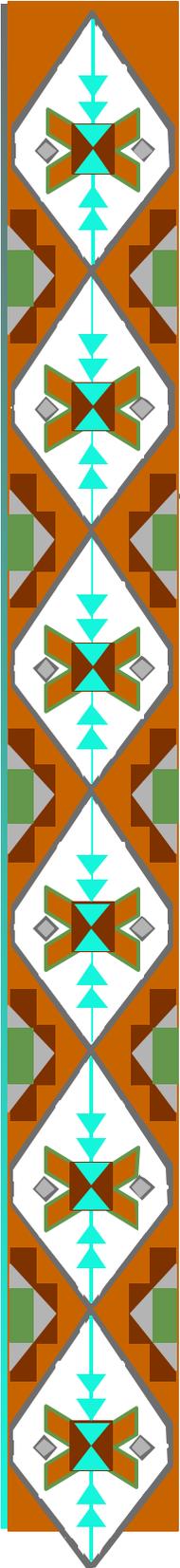
# Permitting Bioreactors

**Nancy Pate, DVM, MPH**  
**Mohamed Serageldin, Ph.D.**



**2003 Air Toxics Implementation Workshop**

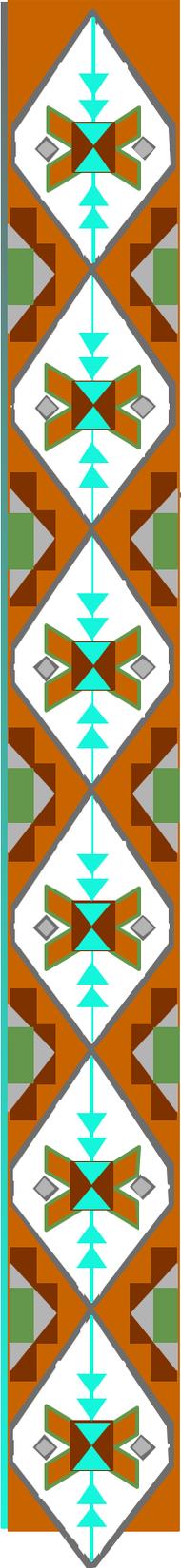
April 7-10, 2003 - Hilton  
North Raleigh in Raleigh, NC



# HISTORICAL

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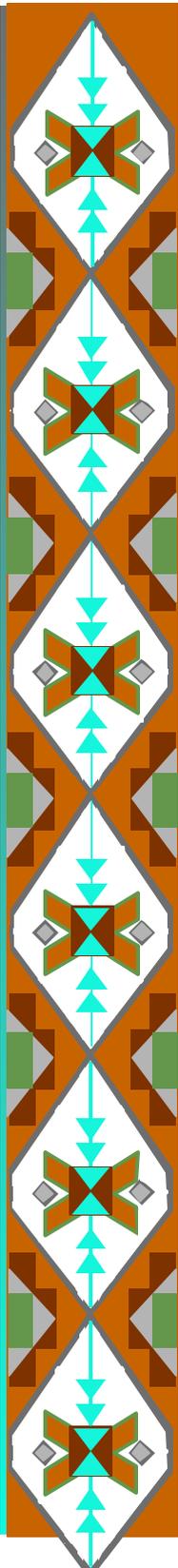
- 1992 OAQPS (ESD)
- 1993 Participated at meetings with the Wood furniture industry, and NCSU
- 1997 Air Bioreactor meeting at RTP
- 1997 Setup OAQPS website, including costing software
- Other EPA activities
  - Funded study using ORD's water trickling bioreactor prototype
  - Setup bioreactor study under ORD's ETV Program with Research Triangle Institute



# OBJECTIVES

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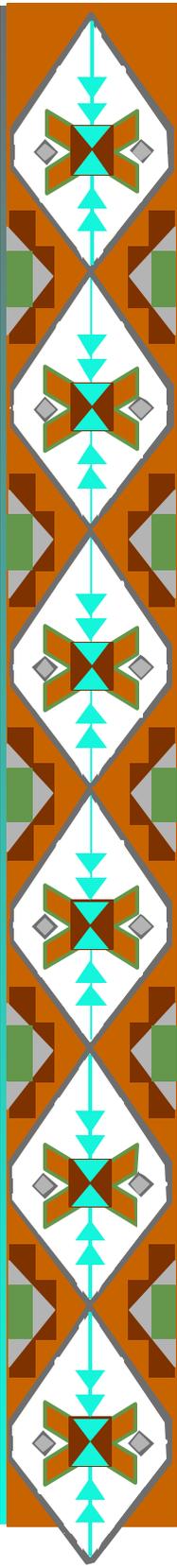
- Overview bioreactor systems
- Identify Parameters to Monitor
- Discuss Permitting Aspects



# A BIOREACTOR FOR AIR POLLUTION CONTROL

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- Micro-organisms are used to bio-oxidize pollutants such as HAPs and VOCs in air streams
- Most systems in use were built to address odor problems ( $< 50$  ppmv)
- Fewer systems were built in the U.S. for VOC or HAP control ( $> 50 - 1000$  ppmv)



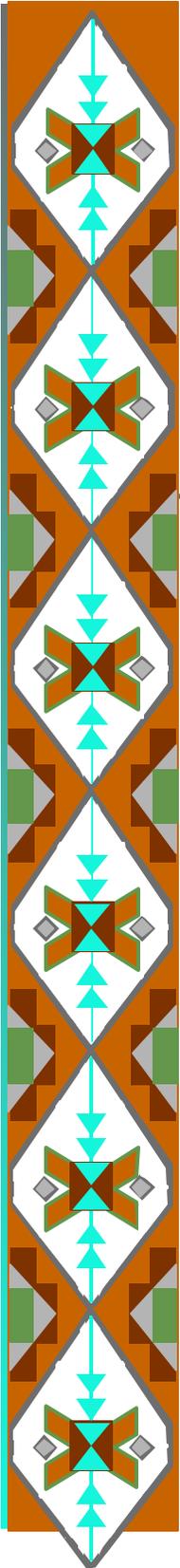
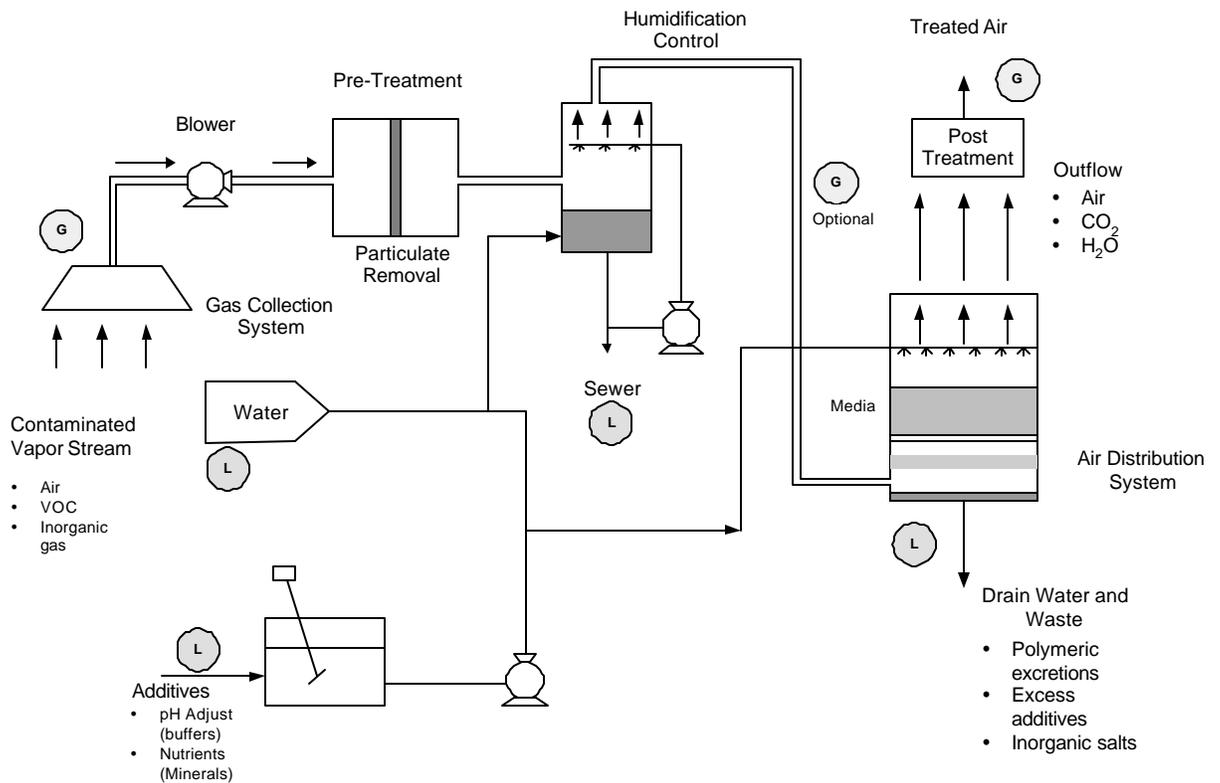
## THERE ARE SEVERAL DESIGNS

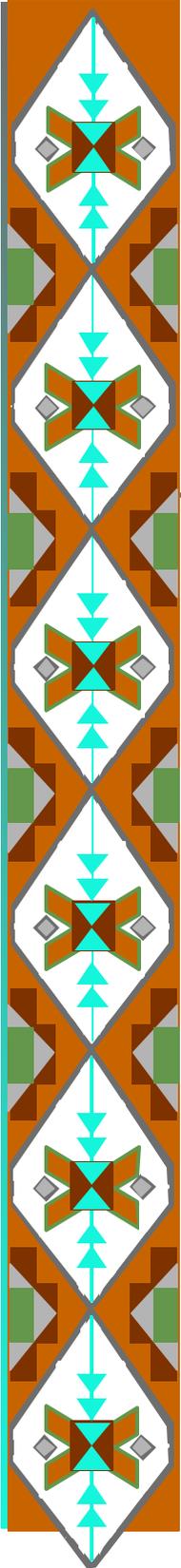
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- Packed bed bioreactor system
  - (open or closed)
- water trickling bioreactor system
- absorption bioreactor system
- rotating drum bioreactor system
  - (activated carbon or inert bed)
- membrane bioreactor system

# A BIOREACTOR SYSTEM

Courtesy of Bob Zerbonia, RTI

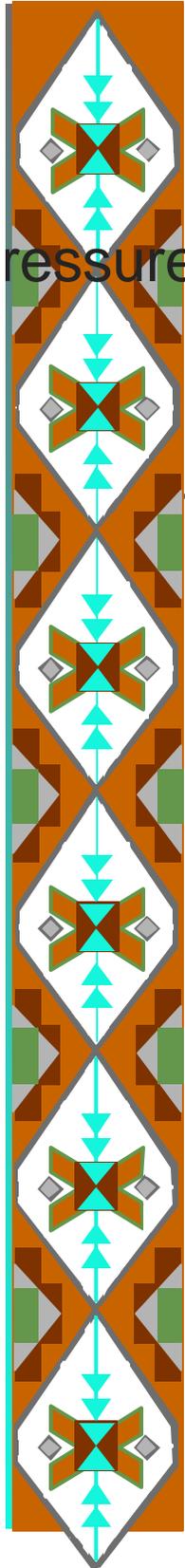




# QUALIFYING PARAMETERS

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- Elimination Capacity (g/m<sup>3</sup>/day)
  - $EC = (C_i) (Q_{\text{gasflow}}) / (V_{\text{bed vol.}})$
- Destruction Efficiency (%)
  - $\text{Efficiency} = 100 (C_i - C_o) / C_i$
- Regulations define capture and destruction efficiencies
- EC influences size and cost of bioreactor unit

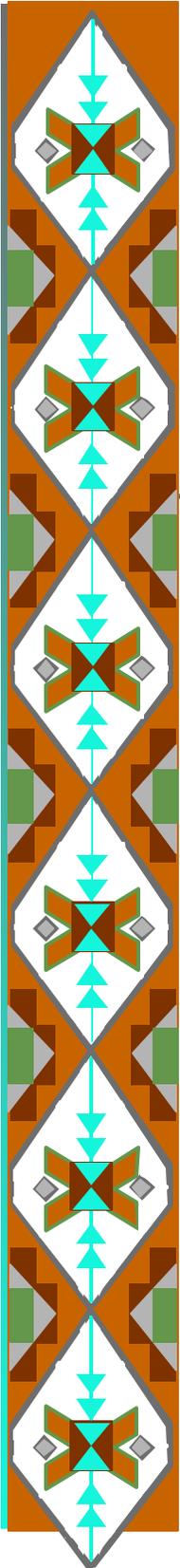


pressure drop

## IMPORTANT PARAMETERS

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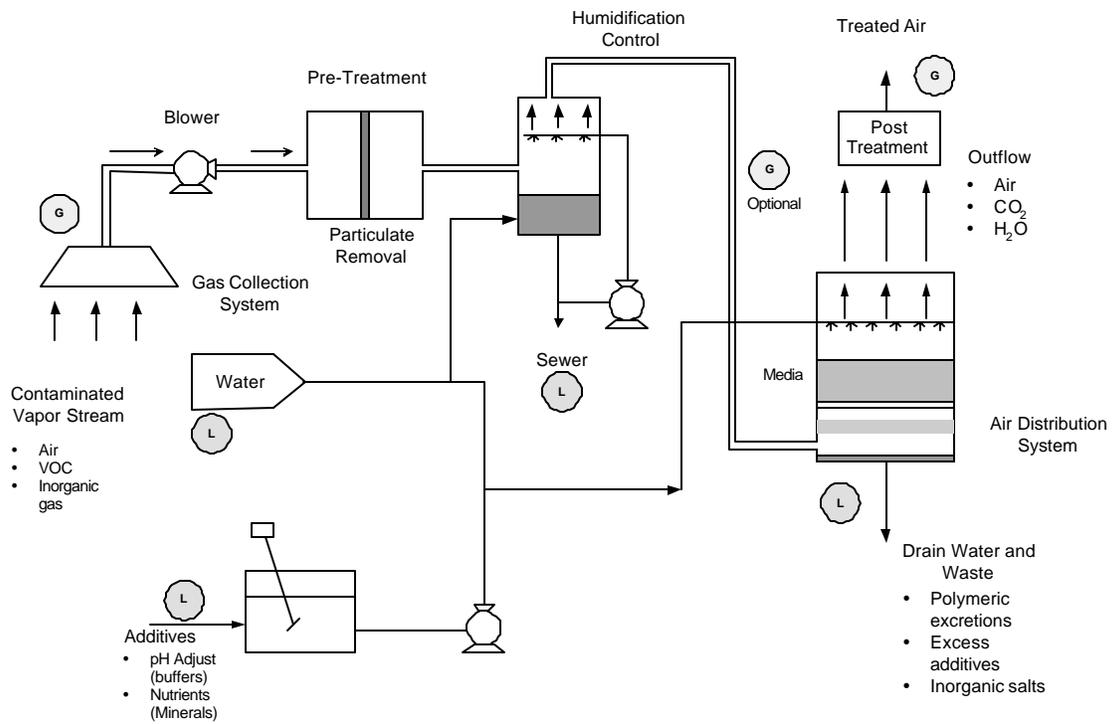
- Composition and amount of pollutants
- Microorganism mix
- Humidity (or moisture content)
- Temperature
- p-H value in the bio-layer
- Pressure drop

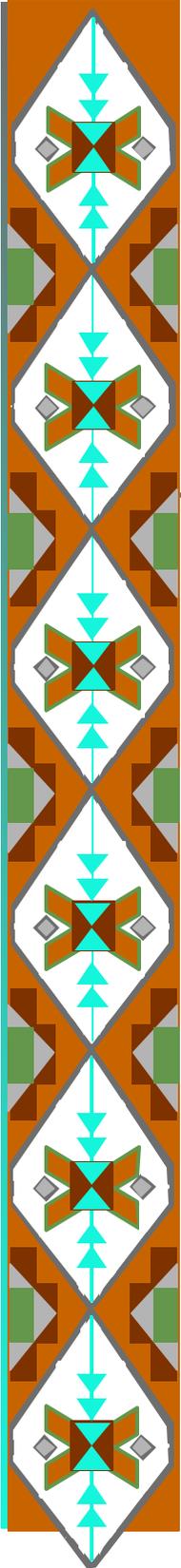


# MONITORING

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- Control Parameters
  - capture efficiency
  - gas inflow
  - gas outflow
- Operational Parameters
  - water inflow (humidity)
  - temperature
  - p-H control
  - pressure drop
  - biomass buildup
  - flow fluctuations

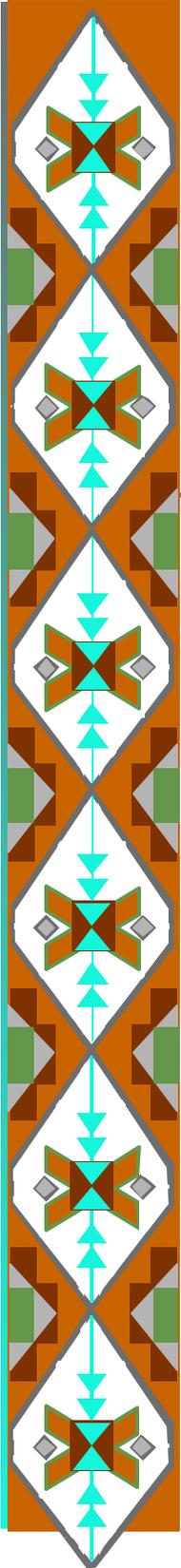




# TEST METHODS

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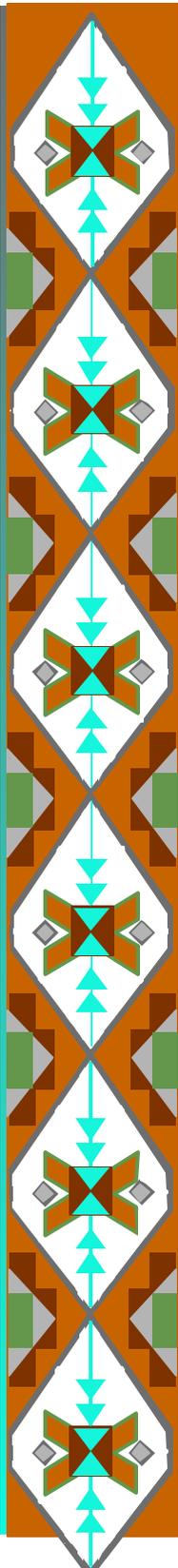
- Capture Efficiency
  - Temporary TE - EPA Method 204 D
  - Building enclosure - EPA Method 204 E
  - Alternative approved protocol
- Destruction Efficiency (depending on rule)
  - EPA Methods 25 or 25 A
  - EPA Method 311
  - EPA Method TO-11 (Aldehydes)
  - EPA Method TO-12 (Total Non methane Organics)
  - EPA Method TO-14 (Chlorinated and non Chlorinated Aromatics)



# RECORDKEEPING AND REPORTING

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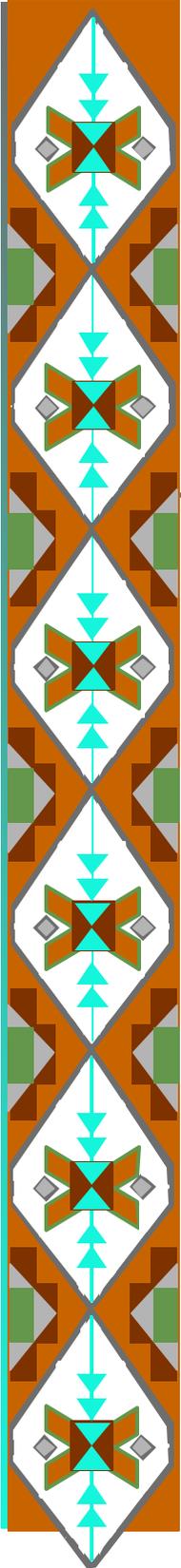
- Need to keep compliance calculations and monitoring records per rule requirements.
- Records are often retained in digital format, including manufacturer's data sheets.
- Digital reporting.



## CONCLUDING REMARKS

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- Most industrial sized units are built for odor control.
- We are not aware of any system that was built for regulatory purposes.
- Size and Cost are influenced by
  - pollutant load and the desire for biomass control
  - type of flow (continuous or intermittent)



## SUPPLEMENTARY INFORMATION

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- Helpful documents
  - *Biofiltration*, Center for Waste Reduction Technologies, AIChE, New York, 1999.
  - Deviney, J.S; Dehusses, M.A; T.S. Webster *Biofiltration for Air Pollution Control*, Lewis Publishers, New York, 1999.
- Websites
  - [http://www.epa.gov/ttn/atw/bio/bio\\_rsch.htm](http://www.epa.gov/ttn/atw/bio/bio_rsch.htm)
  - <http://etv.rti.org/apct/tech/voc/>