Biofiltration

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Discussion Topics

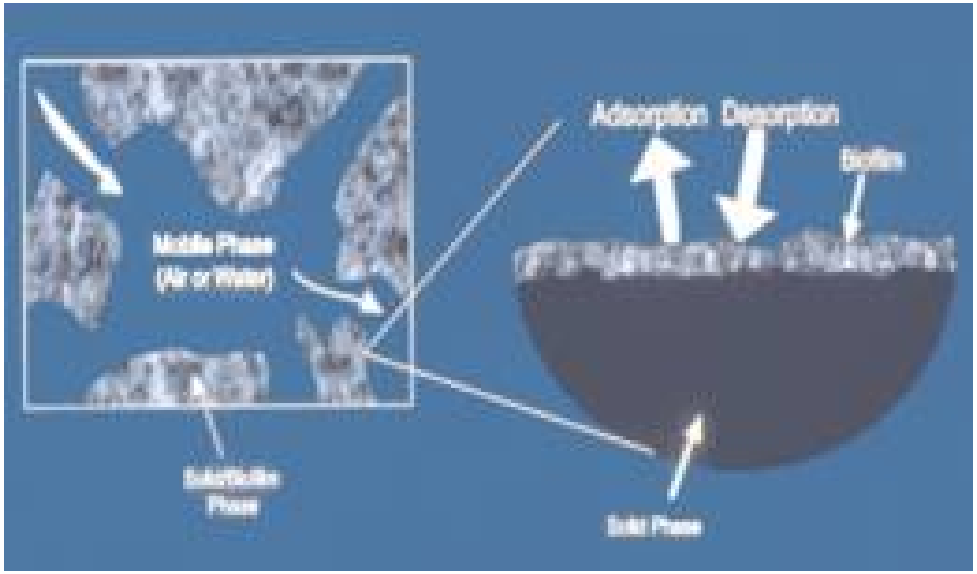
- Biological Treatment of Wastewater Odors
- History and Development of Biological Odor Treatment
- Biofilters
- Media Options and Preferences

Biological **Odor** Treatment

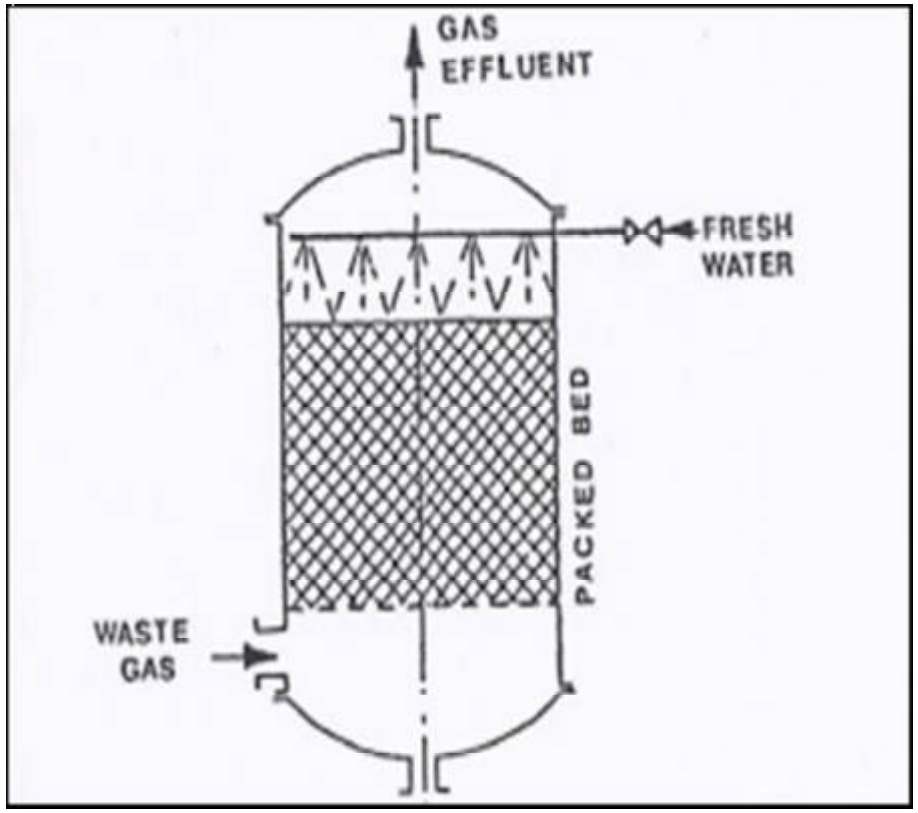
- Biogenic Odors
  - Inorganic Reduced Sulfur
    - Hydrogen Sulfide (H_2S): Rotten Egg Odor, 0.5-1 ppb Detection level
  - Organic reduced Sulfur
    - Mercaptan
      - Methyl Mercaptan (CH_2SH): Cabbage Odor, ~1 ppb Detection Level
      - Ethyl Mercaptan (C_2H_5SH): Oniony/Garlic Odor, ~1 ppb Detection Level (Nat Gas)
    - Organic sulfides
      - Dimethyl Sulfide (C_2H_6S): Decaying meat/vegetables, ~1 ppb Detection Level
      - Dimethyl Disulfide ($C_2H_6S_2$): Sweet Od0r of decaying Cabbage/Vegetables, ~1 ppb Detection Level
  - Inorganic Nitrogen
    - Ammonia (NH_3): Characteristic Pungent, 5 – 50 ppm (OSHA)
  - Organic Nitrogen
    - Amines (RNH_2): Fishy, 5 – 50 ppb
    - Skatole (C_9H_9N) & Indole (CH_8H_7N) (Proteins): Intense Fecal Odor,

Biological Odor Treatment Process

- Biofilters
  - Immobilized microflora
  - Stationary Aqueous Phase
- Biotrickling Filters
  - Immobilized microflora
  - Mobile Aqueous Phase
- Bioscrubbers
  - Dispersed Microflora
  - Mobile Aqueous Phase



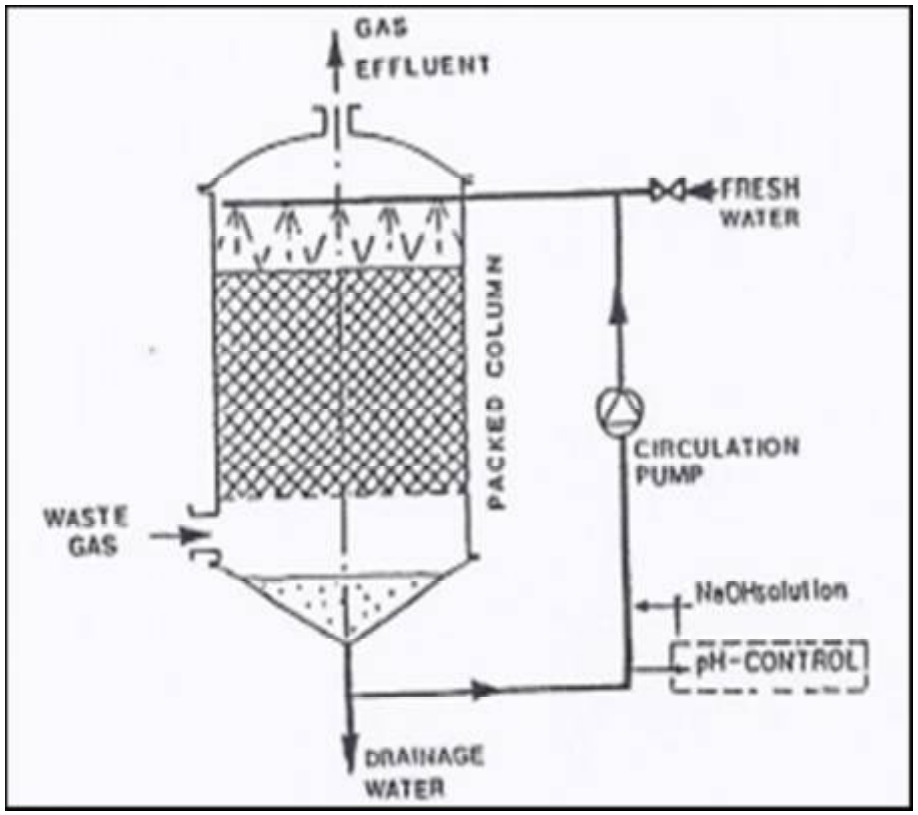
Biofilter



Biofilter Filter (copied from Diks and Ottengraph1)

- Designed in a trench, bermed structure, or vessel
- Utilize organic media such as composted green matter and woodchips. Inorganic media in modern designs.
  - Requires only passive acclimation
- Irrigation critical may be internal or external
- Designed around 3- 4 cfm/ft^2 and 3 - 4 ft deep (35 - 60 sec residence time)
- Media life limited to <5 years.
- Requires maintenance to keep moisture and airflow consistent.

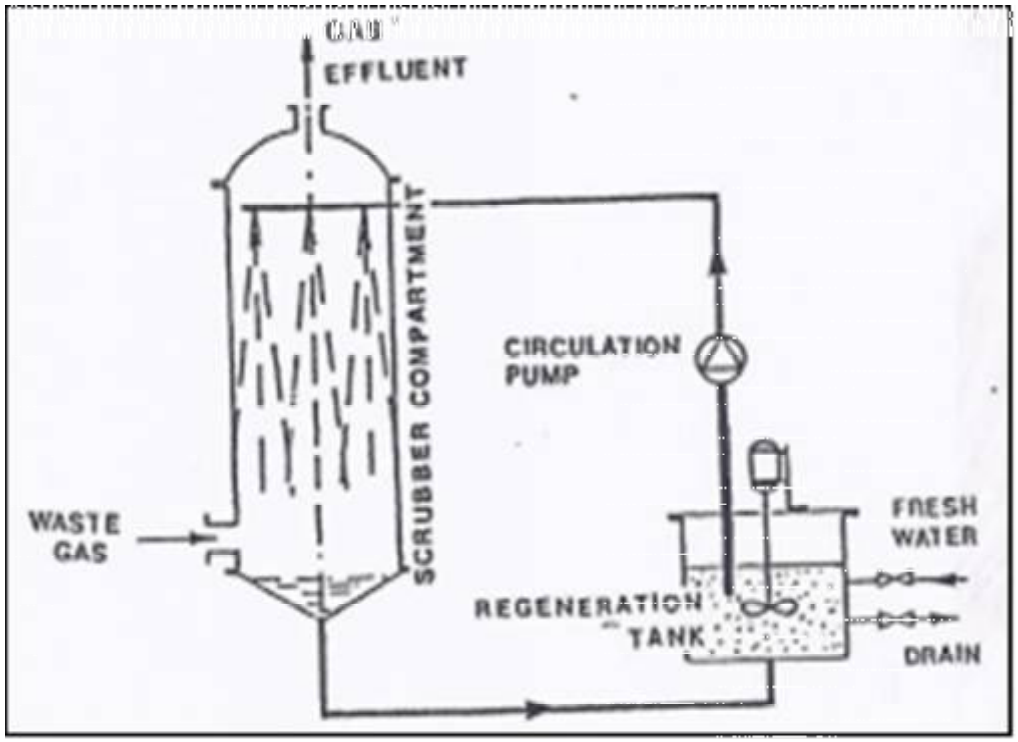
Biotrickling Filter



Biotrickling Filter (copied from Diks and Ottengraph[1])

- **Countercurrent design with water flowing downward and air traveling upward**
- **Plastic media**
  - **Requires active acclimation**
- **Increased mass transfer due to improved air distribution and irrigation**
- **Light weight media allows for vertical stages.**
- **Up to 100 cfm/ft^2 (Sewage Odor) loading rate at <100 ppm H_2S. And >100 ppm with lower loading rate (cfm/ft^2)**

Bioscrubber



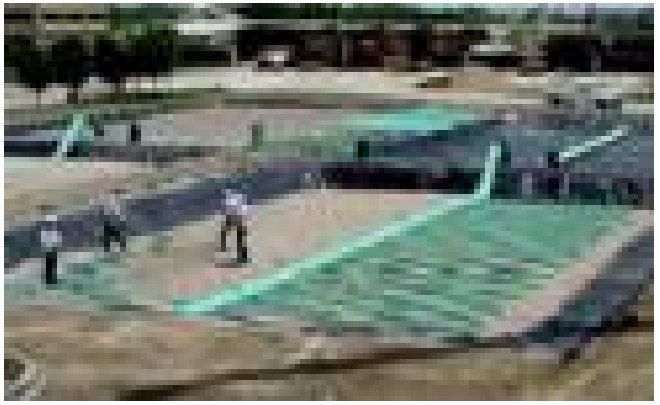
- Countercurrent design with water flowing downward and air traveling upward
- Plastic media
  - Requires active acclimation
- Increased mass transfer due to improved air distribution and irrigation
- Separate mass transfer and reaction areas
- Up to 100 cfm/ft^2 (Sewage Odor) loading rate at <75 ppm H_2S. And >100 ppm with lower loading rate (cfm/ft^2)

Biofiltration History: USA

- 1934 Earliest patents for biofiltration
- First biofilters in the United States (From: Identifying and Controlling Odor in the Municipal Wastewater Environment, Phase 1: Literature Search and Review, WERF 2003))
  - 1994 LaBeau and Milligan: Top soil, peat, cypress/wood mulch for the control of H_2S
  - 1997 Vaith and Haydorn investigated and compared the operation of two biofilters used on wastewater pumping stations.
  - 1997 Montgomery Watson Proposes biofilters for Memphis TN wastewater odor
- Modular Biofilters
  - 1997 Biocube Patent for modular tray system
  - 1998 Biorem Patent for Biosorbens synthetic media
  - 1998 CVT America Patent for biofilter with modular panels
- Biological Treatment
  - Several patents and proprietary design for synthetic media systems

Organic Media Biofilters

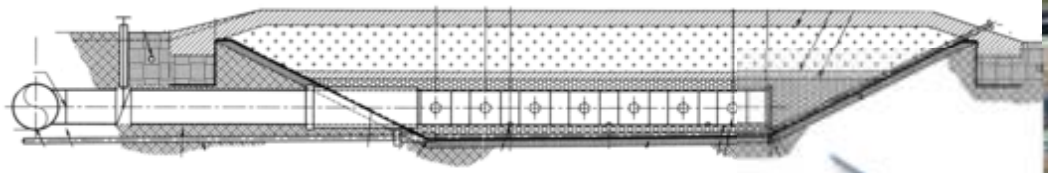
- Mechanical Design; Key to Success
  - Air Distribution
    - Perforated Pipe
      - Design for constant pressure drop
      - FRP pipe: corrosion barrier on all sides
    - HDPE Floor System
  - Irrigation System
    - Single level
    - Multi level
      - Industrial solvents
  - Drainage
    - Bottom drains
    - Containment
      - Concrete
      - Plastic reinforced HDPE pond liners



Organic Media Biofilters

- Environmental Control
  - Extends media life
  - Concrete bottoms and sides
    - Controls subsidence
    - Controls drainage
  - Canopies
    - Maintains media consistency
  - Enclosed
    - Modular

Biofilters



Modular Biofilters

Enclosed Biofilters

Biotrickling Filters and Bioscrubbers

Organic Biofilter Media Support Material

- Stabilized Woodchips
  - C/N ratio: 400/1
  - Relatively Resistant to biological breakdown
  - Low aspect ratio :W/L
- Stabilized Bark
  - C/N ratio: 490/1
  - Relatively Resistant to biological breakdown
  - High aspect ratio: W/L

Biofilter Media Support Material

- Avoid Processed Construction and Demolition material
  - Usually poorly and unevenly processed
  - May contain hazardous material, adhesives, metals

Biologically Active Component

- Compost

  - Low C/N ratio: 20-30
  - Partially degraded organic material
  - Mineralized organic matter
  - High biological component
    - 10^9 bacteria /gm compost
    - Autotrophs: Sulfur oxidizers
    - Wide variety of heterotrophic organisms

Biofilter Media Design

Optimum Media Mixture

- 80% - 90% support material
  - Fir bark
- 10 - 20% composted material
- pH 6-8
- Moisture 40%

- Media Depth
  - 42 in
- Humidification and Irrigation
  - Surface irrigation with humidification
  - Multilayered irrigation without humidification

Biofilter Media Design

Utility Media Mixture

- 80% - 90% support material
  - wood chips or composting overs
- 10 - 20% composted material
- pH 6-8
- Moisture 40%

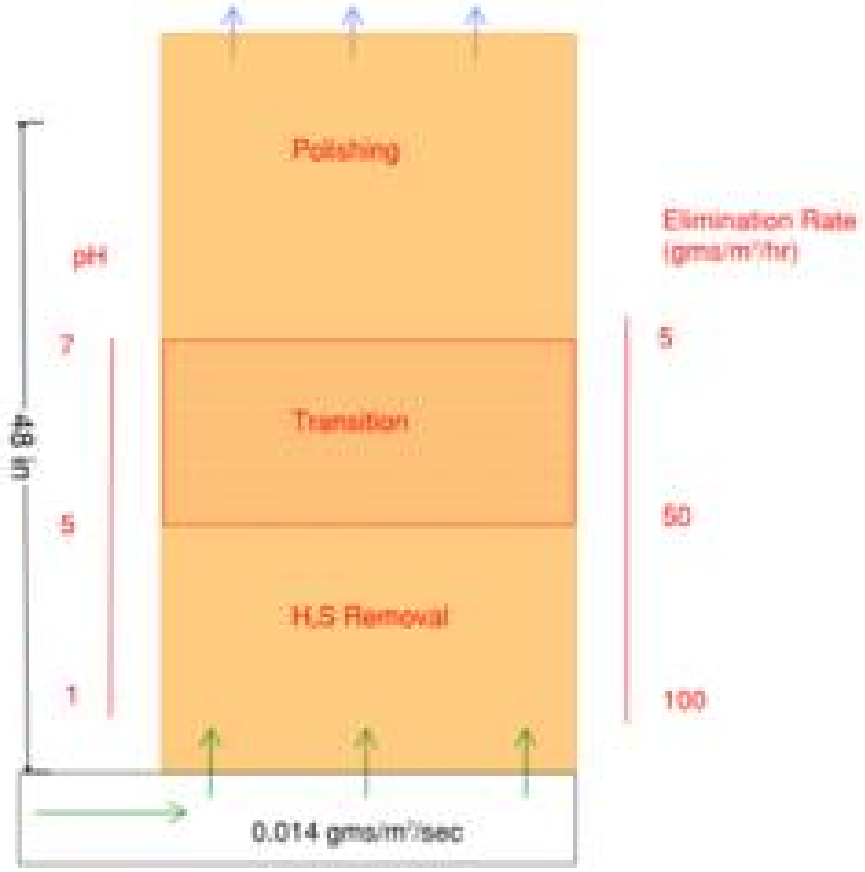
- Media Depth
  - 42 in
- Humidification and Irrigation
  - Surface irrigation with humidification
  - Multilayered irrigation without humidification

Bark Media Bed

Woodchip Media Bed

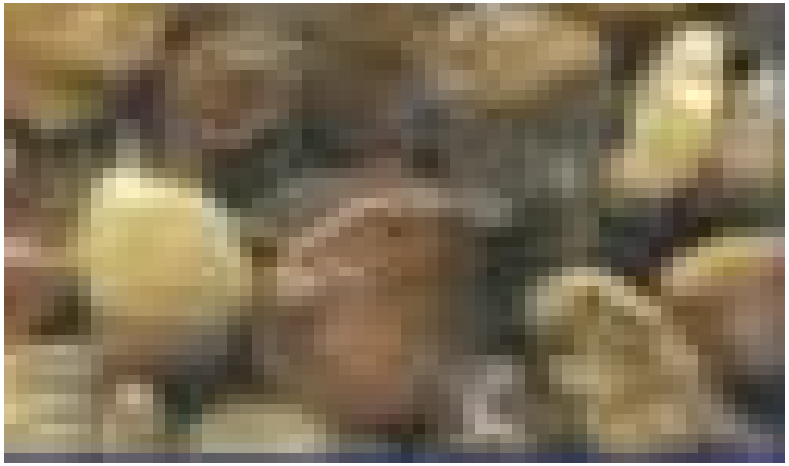
No Maintenance Media Bed

- Theoretical Elimination Capacity (EC) for biofilters:
  - Up to 150 gms $H_2S_{removed}/m^3_{media}/hr$
- The biofilter operates between the theoretical maximum and a minimum i.e. 5 gms $H_2S_{removed}/m^3_{media}/hr$ as a function of:
  - H_2S level
  - Diffusion
  - Biological activity
  - Temperature



Inorganic media: Soil Media

- Proprietary mixture of inorganic material
- Considered permanent
- The same mechanical considerations apply
  - Air and water distribution



Inorganic Media Biofilters

- Proprietary media using a combination of a highly refractory support media with nutrient
- 30-40 sec EBRT
- Steady pressure drop (<3 in.wc.)
- Carries a long media warrantee of ten year

Inorganic Media Biofilters

- Completely enclosed
- Operated as biofilters generally with a humidification systems and sparse irrigation
- Limited to 50 ppm H_2S
- Effective on organic reduced sulfur compounds and VOCs

Conclusions

- Biofiltration is a basic but effective odor control technique when simple rules are followed
  - Careful attention to mechanical design of air and water distribution
  - Blending of media with a maximum of 20% organic compost, with less biodegradable material providing the remaining 80% of the mixture
    - Stratifying media is effective with complex airstreams
  - Protect biofilters from the elements
    - Canopies
    - Concrete enclosures
    - Covers
  - Limit the H2S levels intended for treatment
    - <50 ppm provides adequate polishing of residual odors
    - <50 ppm provides the maximum media life
  - Biofilters are low maintenance not no maintenance
  - When it's done it's done, don't top up the media bed after the first year. Plan on replacement after three years