4.7 BIO-FILTRATION

- Bio-filtration is a pollution control technique using a bioreactor containing living material to capture and biologically degrade pollutants.
- Common uses include processing waste water, capturing harmful chemicals or silt from surface runoff, and microbiotic oxidation of contaminants in air

Examples of bio-filtration include:

- Bioswales, biostrips, biobags,bioscrubbers, Vermifilters and trickling filters
- Constructed wetlands and natural wetlands
- Slow sand filters
- Treatment ponds
- Green belts
- Green walls
- Riparian zones, riparian forests, bosques
- Bivalve bioaccumulation

Control of Air Pollution using Bio-Filters:

When applied to air filtration and purification, Bio-filters use microorganisms to remove air pollution. The air flows through a packed bed and the pollutant transfers into a thin biofilm on the surface of the packing material. Microorganisms, including bacteria and fungi are immobilized in the biofilm and degrade the pollutant. Trickling filters and bio-scrubbers rely on a biofilm and the bacterial action in their recirculating waters.

- The technology finds greatest application in treating malodorous compounds and water-soluble volatile organic compounds (VOCs).
- Industries employing the technology include:
  - Food and animal products
  - Off-gas from wastewater treatment facilities
  - Pharmaceuticals

- Wood products manufacturing
- Paint and coatings application
- Manufacturing and resin manufacturing .

- Compounds treated are typically mixed VOCs and various sulfur compounds, including hydrogen sulfide.
- Very large airflows may be treated and although a large area (footprint) has typically been required a large biofilter (>200,000 acfm) may occupy as much or more land than a football field this has been one of the principal drawbacks of the technology.
- Engineered biofilters, designed and built since the early 1990s, have provided significant footprint reductions over the conventional flat-bed, organic media type.
- One of the main challenges to optimum biofilter operation is maintaining proper moisture throughout the system.
- The air is normally humidified before it enters the bed with a watering (spray) system, humidification chamber, bio-scrubber, or biotrickling filter.
- Properly maintained, a natural, organic packing media like peat, vegetable mulch, bark or wood chips may last for several years but engineered, combined natural organic, and synthetic component packing materials will generally last much longer, up to 10 years.
- A number of companies offer these types or proprietary packing materials and multi-year guarantees, not usually provided with a conventional compost or wood chip bed bio-filter.
- The scientific community is still unsure of the physical phenomena underpinning bio-filter operation, and information about the microorganisms involved continues to be developed.

A bio-filter/bio-oxidation system is a fairly simple device to construct and operate and offers a cost-effective solution provided the pollutant is biodegradable within a moderate time frame (increasing residence time = increased size and capital costs), at reasonable concentrations (and lb/hr loading rates) and that the airstream is at an organism-viable temperature.

- For large volumes of air, a bio-filter may be the only cost-effective solution.
- There is no secondary pollution (unlike the case of incineration where additional CO_2 and NO_x are produced from burning fuels) and degradation products form additional biomass, carbon dioxide and water.
- Media irrigation water, although many systems recycle part of it to reduce operating costs, has a moderately high biochemical oxygen demand (BOD) and may require treatment before disposal.
- This "blowdown water", necessary for proper maintenance of any bio-oxidation system, is generally accepted by municipal publicly owned treatment works without any pretreatment.
- Bio-filters are being utilized in Columbia Falls, Montana at Plum Creek Timber Company's fiberboard plant.
- The bio-filters decrease the pollution emitted by the manufacturing process and the exhaust emitted is 98% clean.
- The newest, and largest, bio-filter addition to Plum Creek cost $9.5 million, yet even though this new technology is expensive, in the long run it will cost less overtime than the alternative exhaust-cleaning incinerators fueled by natural gas (which are not as environmentally friendly).

Types of Bio-Filters:

1. Fixed Bed Bio-filters

- Fixed Bed Bio-filters consist of a filter material that may be synthetic or organic, which serves as support for the microorganisms.
- Some of the filter materials that may be used are porous rock, diatomaceous earth, perlite, and ground wood chips as well as different types of compost or organic waste.
- Fixed bed bio-filters operate by passing a humidified gas stream containing the contaminants through the bed where they are degraded by the microorganisms.
- This is recommended for treating contaminants poorly soluble in water due to the absence of the aqueous phase.

- It is important to note that the physical footprint of fixed bed bio-filters is greater than other types of bio-filters.

2. Drained Bed Bio-filters

- Drained Bed Bio-filters consist of a packed column with an inert support where biofilm develops.
- Through the bed, a gaseous stream is fed that contains the substrate to biodegrade in addition to a liquid stream that is continually recycled through the bed.
- This liquid stream has the function of providing nutrients to the biofilm, as well as removing the degradation products of the microorganisms.
- These systems are recommended for water-soluble compounds.
- The recirculation of fluid facilitates the elimination of the reaction products as well as better control over the biological process by pH control and composition of the liquid medium.
- Drained bed bio-filters are the equipment with the smallest physical footprint in addition to being simple to operate.

3. Bio scrubbers

- The compound to be degraded first is absorbed in the liquid phase located in an absorption tower filled with liquid.
- The operation involves making the gas flow in a countercurrent through the liquid where the contaminants and oxygen are absorbed.

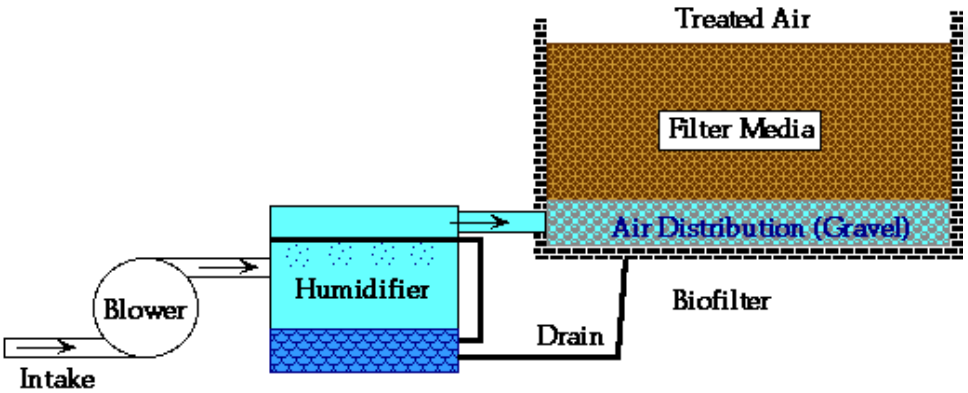

Figure 4.7.1Biofilter Schematic

[Source:http://compost.css.cornell.edu/odors/biofilter.gif]

- The liquid is fed to a reactor packed with an inert material covered with biofilm that is responsible for degrading the pollutant.
- Bio-scrubbers are the most suitable systems for the treatment of highly water-soluble compounds.
- Their advantage in respect to biofilters is that they do not accumulate products that can have harmful effects on the microorganisms.
- They facilitate control of the biological process through the composition of the liquid medium.

However, bio-scrubbers are more costly because they require two systems, one for absorption and one for the biodegradation of the contaminant, therefore making them less economical than drained bed bio-filters.

The selection of the most appropriate system depends on the characteristics of the gas stream being treated, the expected removal efficiency and the costs involved.

Parameters of Bio-Filtration:

The main parameters to consider when designing a Bio-filtration system are:

- The characteristics the gas contaminate (concentration, flow, particulate matter, temperature)
- Selection of filter material
- Moisture content of the filter material
- Microorganisms