International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 09 | Sep 2020 www.irjet.net p-ISSN: 2395-0072

# PURIFICATION OF GASEOUS POLLUTANTS USING BIOFILTRATION TECHNIQUE

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**Abstract:** *A study says over 300 different chemical species are present in air which may adversely affect the environment and health of an entire population. Biofiltration is an attractive technique for the elimination of malodorous gas emissions and of low concentrations of volatile organic compounds (VOCs). The process involved (Bio reaction) is totally a green process while the use of Biofiltration in India is very less as compared to other countries like Europe, Netherland and Japan. A biofilter's main function is to bring micro-organisms into contact with pollutants contained in air stream and it contains a filter material, which is the breeding ground for the micro-organisms. The purpose of this review paper is to spread the biofiltration technique and should be installed in every industry so that the gaseous pollutants gets cleaned up and goes into the environment.*

***Key Words:*** **Bio filtration, Bio filter, VOCs, micro-organisms, contaminated gas, Green Process**.

## 1. History:

| | |
|---|---|
| 1923 - | Biological methods were proposed to treat odorous emissions. |
| 1955 - | Biological Methods were applied to treat odorous emissions in low concentrations in countries of Europe. |
| 1960's - | Biofiltration was used for the treatment of gaseous pollutants both in Europe and US. |
| 1970's - | Biofiltration is used with high success in Country like Germany. |
| 1980's - | Biofiltration is used for the treatment of toxic emissions and volatile organic compounds(VOCs) from industry. |
| 1990's - | Today there are more than 500 biofilters operating both in Europe and Netherland and now a days widely used in US. |

## 2. Introduction:

Biofiltration is a new emerging technology applied to treat contaminated air containing biodegradable volatile organic compound (VOCs) or inorganic toxics. It is highly used in other countries like USA & Europe since 40 years but why not in India?

Pollution caused by VOC and other air pollutants like odorous compounds, organic & inorganic compounds including nitrogen and sulphur containing compounds have adverse effect on humans as well as on environment. Various odor emissions sources are shown in table-1 and various types of odorous compound are shown in table-2. More than 100 kinds of odorous gases are emitted from different processing and manufacturing units.

Unlike conventional technologies such as adsorption, scrubbers & incineration; biofiltration allows effective pollution control at relatively low capital and operating costs. Other biotechnologies like biotrickling filters and bio-scrubbers have been attracting an increasing popularity as a clean technology, they reduce/eliminate the need for additional treatment of the end products.

| Scales of Odour | Emission Source | Odour Emission rate ($m^3/m$) | Distance of Influence (m) |
|---|---|---|---|
| **Large** | Pulp factory, Rendering plants, Fish meal plant, Rayon factory etc | $10^7$-$10^9$ | 1000-5000 |
| **Middle** | Poultry farms, night soils, wastewater treatment plants, coffee baking factory, car coating factory, metal coating factory, composting facility, rubber factory etc | $10^5$-$10^6$ | 50-1000 |
| **Small** | Restaurants, bakery, laundry, hair dresser, car repair shops, garbage collection shops, public lavoratory, septic tanks etc | $10^4$ or less | 5-500 |

**Table-1: Various odour emission sources**

| Compound/Odorant | Formula | Offensive Odour | Odour Threshold(PPB) |
|---|---|---|---|
| **1) Inorganics** | | | |
| ➢ *Ammonia* | *NH3* | *Pungent, Irritating* | *17* |
| ➢ *Chlorine* | *Cl2* | *Pungent, Suffocation* | *0.08* |
| ➢ *Hydrogen sulphide* | *H2S* | *Rotten eggs* | *0.0047* |
| ➢ *Ozone* | *O3* | *Pungent, irritating* | *0.5* |
| ➢ *Sulphur dioxide* | *SO2* | *Pungent, irritating* | *2.7* |
| **2) Acids** | | | |
| ➢ *Acetic acid* | *CH3COOH* | *Vinegar* | *1.0* |
| ➢ *Butyric acid* | *CH3CH2CH2COOH* | *Rancid butter* | *0.12* |
| ➢ *Propionic acid* | *CH3CH2COOH* | | *0.028* |
| **3) Amines** | | | |
| ➢ *Methyl amine* | *CH3NH2* | *Putrid, fishy* | *4.7* |
| ➢ *Ethyl amine* | *C2H5NH2* | *Ammonical* | *0.27* |
| **4) Mercaptans** | | | |
| ➢ *Allyl Mercaptan* | | *Disagreeable, Garlic* | *0.0015* |
| ➢ *Amyl Mercaptan* | *CH2CHCH2SH* | *Unpleasant, Putrid* | *0.0003* |
| ➢ *Benzyl Mercaptan* | *CH3(CH2)4SH* | *Unpleasant, Strong* | *0.0002* |
| ➢ *Ethyl Mercaptan* | *C6H5CH2SH* | *Decayed Cabbage* | *0.0003* |
| ➢ *Methyl Mercaptan* | *C2H5SH* *CH3SH* | *Rotten Cabbage* | *0.0005* |
| **5) Sulphides** | | | |
| ➢ *Diethyl Sulphide* | | *Ether* | *0.02* |
| ➢ *Dimethyl Sulphide* | *(C2H5)2S* | *Decayed Cabbage* | *0.001* |
| ➢ *Dimethyl Disulphide* | *(CH3)2S* *(CH3)2S2* | *Putrid* | *0.028* |

| | | | |
|---|---|---|---|
| **6) Alcohols** | | | |
| ➢ ***Amyl Alcohol*** | ***C5H11OH*** | ***-*** | ***-*** |
| ➢ ***Butyl Alcohol*** | ***CH3(CH2)3OH*** | ***-*** | ***0.1*** |
| ➢ ***Phenol*** | ***C6H5OH*** | | |

**Table no-2: Various types of odorous compounds**

## 3. Principle :

Biofiltration utilizes biologically active media to remove biodegradable VOC's odors and other toxic compounds from the air stream.

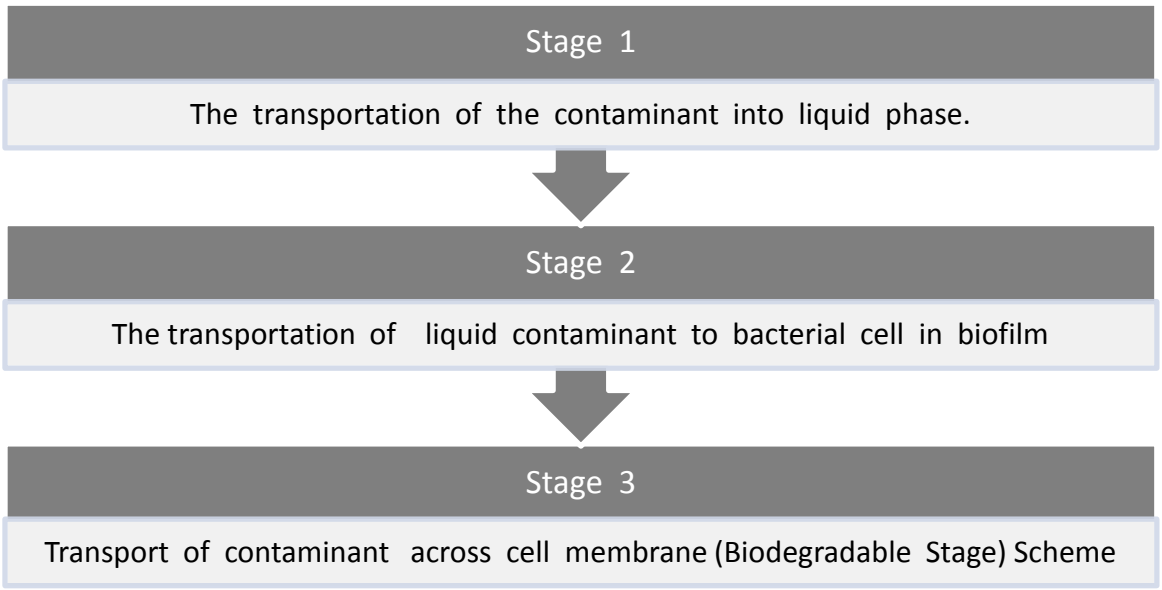
## 4. Materials of construction :

Biofilter is made up of solid support covered by active biofilm, a bed through which the gas with harmful compound passes. Generally, a bed is composed of compost derived from municipal waste, cow dung or soil, where the natural micro-organisms present and helps in degradation of harmful pollutants.

Other materials used in biofilter beds can be peat, woodchips, pine bark or mixture of above materials. Further to increase the biodegradability most common nutrients such as $KH_2PO_4$, $KNO_3$, $(NH_4)_2SO_4$ , $NH_4HCO_3$, $NA_XH_{(3-X)}PO_4$, $CaCl_2$, $MnSO_4$, $MgSO_4$, $FeSO_4$, $Na_2MoO_4$ are used.

## 5. Mechanism:

In biofiltration, the polluted air is passed through a biologically active filter, or biofilter. Microorganisms in the biofilter convert the air pollutants into harmless by products that are primarily carbon dioxide and water. Removal of contaminants is a multistep process, as shown below:




As represented in figure, the treatment process relies basically on two primary fundamental mechanisms:

1) Sorption

2) Biodegradation.

As the contaminated gas steam passes through the bed, contaminants are transferred from the gaseous phase to the liquid or solid phase onto the media. Three possible mechanisms are responsible for this transfer to the phase where the contaminant will degrade:

1. Adsorption on organic media – desorption /dissolution in aqueous phase – biodegradation

2. Direct adsorption in biofilm-degradation

3. Dissolution in aqueous phase – degradation

Once adsorbed in the biofilm layer, or dissolved in the water layer around the biofilm, the contaminant, usually an organic molecule is available as food for the microorganisms metobolism, serving as carbon and energy source for support life a growth. Then the contaminant is exhausted from the biofilter. These physical, chemical and biological phenomena that concur to the contaminated gas treatment happen in an apparatus, which has some special characteristics due to operational variations. Microorganisms live in a bed of biofilter. Packing material consisting of a mixture of rocks, compost, activated sludge, or other hard support material that avoids long-term compaction problems. The bed is housed in an open or an enclosed vessel ranging in size from small 1,000-gallon tanks to large buildings. A blower is used to move the air through the biofilter, and an air dispersion system ensures evenly distributed flow in the bed. High moisture is constantly maintained in the biofilter bed. The ideal operating temperature is 15ºC to 43ºC.

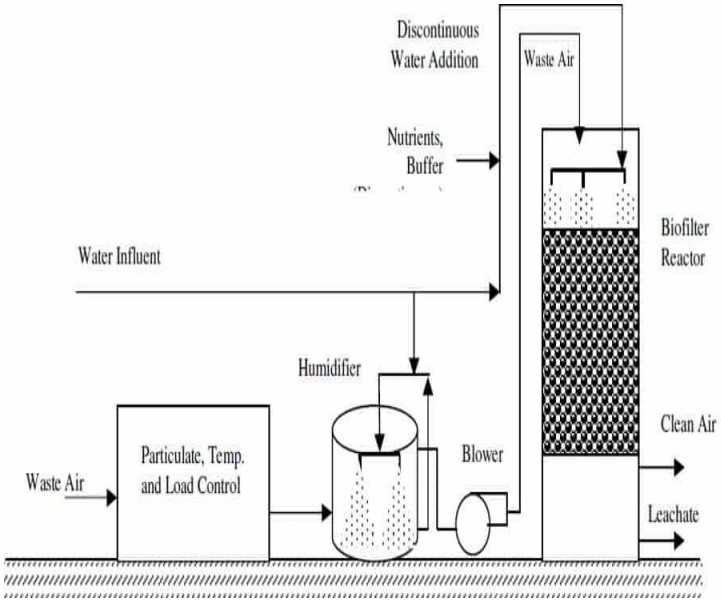



**Fig-1**: Schematic Diagram of Biofilter Unit

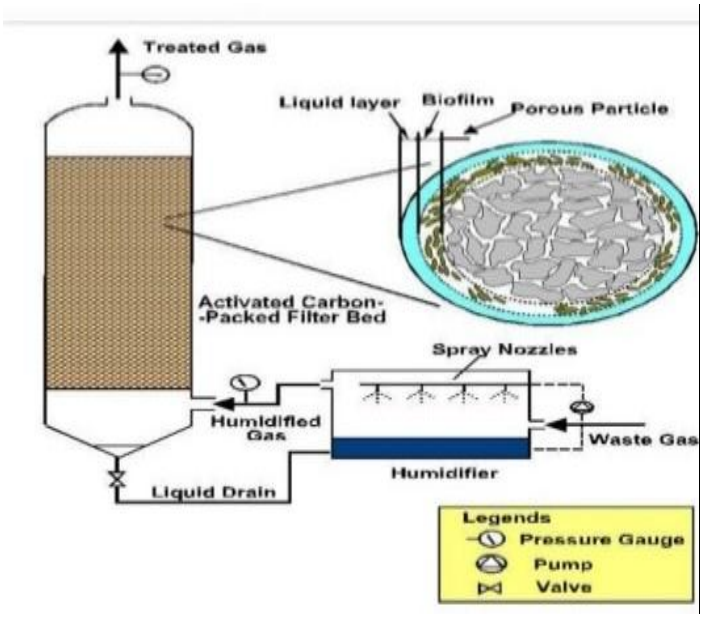



**Fig-2**: Process Diagram of Biofilter Plant

### 6.1 Typical Operating Conditions for Waste Air Treatment in Biofilters

| Sr. no | Parameter | Typical Value |
|---|---|---|
| 1 | Biofilter layer height | 1m |
| 2 | Biofilter Area | 1-3000 $m^2$ |
| 3 | Waste air flow | 50-300000 $m^3$/hr |
| 4 | Biofilter surface loading | 5-500 $m^3 m^{-2} h^{-1}$ |
| 5 | Biofiter volumetric loading | 5-500 $m^3 m^{-2} h^{-1}$ |
| 6 | Bed void volume | Ca. 50% |
| 7 | Mean effective gas residence time | 15-60 s (min.2s) |
| 8 | Pressure drop per meter of bed height | 0.2-1.0 cm C W (max. 10cm) |
| 9 | Inlet pollutant concentration and/or | 0.01-5gm pollutant $m^{-3}$ air 500-500000 OU $m^{-3}$ |
| 10 | Operating temperature | 15-30 °C |
| 11 | Inlet air relative humidity | >98% |
| 12 | Water content of support material | Ca. 60% mass |
| 13 | pH of supporting material | pH 6-8 |
| 14 | Typical removal efficiencies | 60-100% |

**7. Types of Biofilter:**

There are two types of biofilter used in Industries on basis of Layout. They are:
1) Open Bed: Uncovered and exposed to all weather conditions.
2) Closed Bed: Enclosed with a small exhaust part for venting of cleaned air.


**Fig-3**: Types of Biofilter

**8. Applications :**

| Commercial Applications | Industrial Applications |
|---|---|
| 1. VOC Applications to date have included the following industries:<br>• Chemical and Petrochemical industries<br>• Oil and Gas industries<br>• Synthetic Resins<br>• Paint and Ink<br>• Pharmaceutical industries<br>• Waste and waste water treatment<br>• Soil and Groundwater remediation | **McMinnville, Oregon:** The installation in McMinnville, Oregon perhaps best demonstrates the capabilities as the levels of odourous compounds to the highest ever reported from the wastewater treatment environment. |
| | **Long Sault, Ontario:** Although a small (1500 cfm), indoor, container-type system, this installation demonstrates several key aspects that are relevant to any installation |
| | **Sarnia, Ontario:** This biofilter was installed in 2001 and treats 12500 cfm of air coming from a sludge liming and drying operation. |
| 2. Odor abatement applications to date have included the following industries:<br>• Sewage treatment<br>• Slaughter houses<br>• Rendering<br>• Gelatin and glue plants<br>• Agricultural and meat processing<br>• Tobacco, cocoa and sugar industries<br>• Flavour and fragrance | **Brookfield, P.E.I.:** This biofilter was installed in 2002, at a composting plant in P.E.I., that treats 60000 cfm of air from the composting process. |
| | **Toronto, Ontario:** This biofilter was installed in 2002 in the north end of Toronto at the Toronto Mixed Waste Recycling and Organics Processing Facility. |

## 9. Conclusion:

Biofiltration plays very important role in control of air pollution. Biofilter, like all system follow laws of conservation and mass balance and is successful only when microbial ecosystem is healthy and vigorous. Compared to other conventional physico-chemical treatments biofiltration is a versatile technique which is in current usage for the effluent treatment in several developed and developing countries because of the advantages. However, the technique also has some disadvantages which must be seriously considered for the total adoption.

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