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Biofilters – A Novel Technology for Preventing Industrial Pollution

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ABSTRACT

Biofiltration is a contamination control strategy utilizing a bioreactor containing living material to catch and organically degrade toxins. Normal uses incorporate handling waste water, catching harmful chemicals or residue from surface spillover, and microbiotic oxidation of contaminants in air. Biofiltration is a moderately new contamination control innovation. It is an alluring strategy for the eradication of foul-smelling gas discharges and of low concentrations of volatile organic compounds (VOCs). A biofilter's key function is to carry microorganisms into contact with pollutants contained in an air stream. This present paper represents the prevention of industrial pollution with the use of Biofilters.

Keywords: biofiltration, industrial pollution, microorganisms, prevention of air pollution, pollutants

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INTRODUCTION

Biofiltration is an air pollution control technique which involves biodegradation of contaminants under the action of microorganisms diffused in a thin layer of moisture known as "BIOFILM", mainly used for elimination of malodorous gas emissions and low concentrations of volatile organic compounds (VOCs) [1].

The process of biodegradation is

$$\text{Organic Pollutant} + O_2 \rightarrow CO_2 + H_2O + \text{Heat} + \text{Biomass}$$

Biofiltration is a relatively recent air pollution control (APC) technology in which off-gases containing biodegradable volatile organic compounds (VOC) or inorganic air toxics are vented through a biologically active material. This technology has been successfully applied in Germany and The Netherlands in many full-scale applications to control odors, VOC and air toxic emissions from a wide range of industrial and public-sector sources. Control efficiencies of more than 90% have been achieved for many common air pollutants. Due to lower operating costs, biofiltration can provide significant economic advantages over other APC technologies if applied to off-gases that contain readily biodegradable pollutants in low concentrations. Environmental benefits include low energy requirements and the avoidance of cross media transfer of pollutants. This paper reviews the history and current status of biofiltration, outlines its underlying scientific and engineering principles, and discusses the applicability of biofilters for a wide range of specific emission sources [2].

History of Biofilters

The following is a brief timeline of the development of biofilters:

- 1923 – Biological methods were proposed to treat odorous emissions.
- 1955 – Biological methods were applied to treat odorous emissions in low concentrations in Germany.

- 1960s – Biofiltration was used for the treatment of gaseous pollutants both in Germany and US.
- 1970s – Biofiltration is used with high success in Germany.
- 1980s – Biofiltration is used for the treatment of toxic emissions and volatile organic compounds (VOCs) from industry. 1990s – Today, there are more than 500 biofilters operating both in Germany and Netherlands and it is widely spreading in US [3].

Components of Biofilter Unit

- Materials utilized for bed media – peat, treated the soil yard squander, bark, coarse soil, rock, or plastic shapes.
- Support rack – perforated – enable air from the plenum to move into the bed media – to contact organisms that live in the bed. Perforations additionally allow abundance, drain out of the bed to the plenum.
- Fan used to gather contaminated air, as the emissions move through the bed media, the pollutants are consumed by dampness on the bed media. Microorganisms diminish pollutant focuses by expending and utilizing pollutants (Figure 1) [4].

Biofiltration Media

The media used in biofilters can include peat, heather, bark, composted sewage sludge, granular carbon or other suitable materials. The useful shelf life of media is typically five years.

Important Parameters

- Moisture content – Microorganisms require a moist condition. Media tends to dry out on account of the wind stream. Ideal 20–60%.
- Temperature – Microorganisms work best between 30 and 40°C.
- Oxygen level – Most of degradations are oxygen consuming. Oxygen is not utilized specifically in the gas shape however the microorganisms utilize the oxygen introduce in broke down frame in the media.
- pH – For better outcomes must keep up a pH where the microorganism are the most productive.
- Nutrient supply: For high-impact microorganisms, the O:N:P proportion is evaluated as 100:5:1. These are commonly nitrogen, phosphorous, and some follow metals [5].

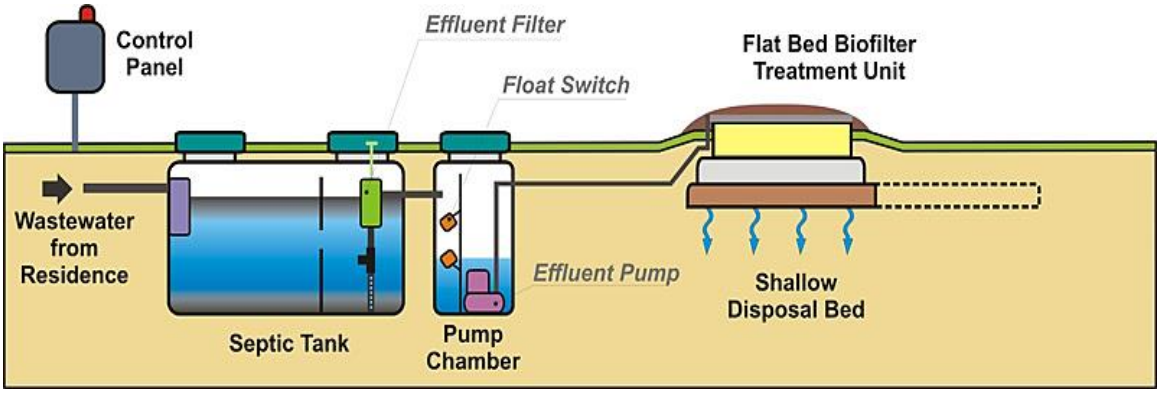

Fig. 1. *Schematic diagram of a biofilter unit.*

Microorganisms

Important microorganisms are fungi, bacteria, and actinomycetes. Startup of a biofilter procedure requires some acclimation time for the microorganisms to develop particular to the mixes in the gaseous stream. For effectively degradable substances, this acclimation period is commonly around 10 days. The biomass has been appeared to have the capacity to be suitable for closed downs of roughly 2 weeks. On the off chance that inorganic

supplement and oxygen supplies are proceeded with, the biomass might be kept up for up to 2 months [6].

Mechanism

Development of the pollutants from the air to the water stage happens. The pollutants in the gas are either adsorbed onto the strong particles of the media or assimilated into the water layer that exists on the media particles. Convergence of pollutants diminishes from channel to outlet as they partitioned between different stages. Waste segment out amongst soil and gas, so that the VOC stay in soil longer than in air. Diffusion occurs through the water layer to the microorganisms in the slime layer on the surface of the media particles. Through biotransformation of the food source, end products are formed, including carbon dioxide, water, nitrogen, mineral salts, and energy. Biotransformation act along with adsorption, absorption, and diffusion to remove contaminants from the gaseous stream (Figure 2) [7, 8].

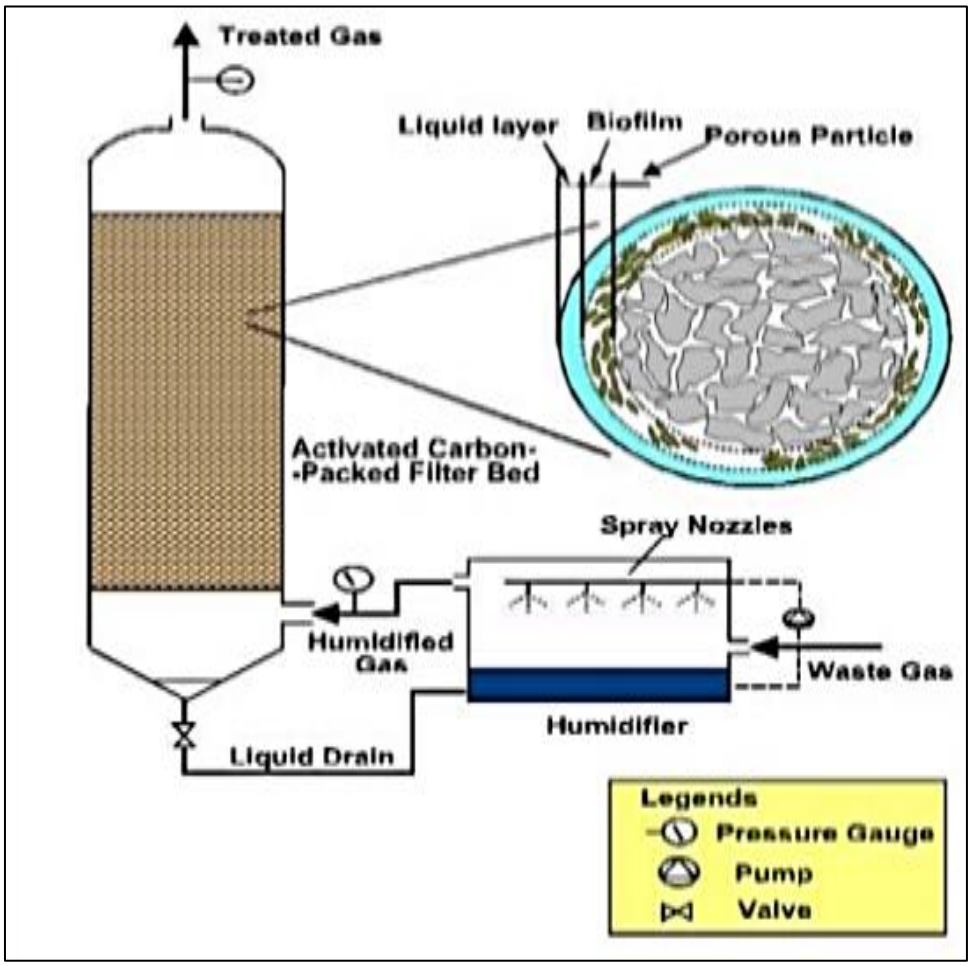

Fig. 2. *Process diagram of a biofilter.*

Biotransformation and Transport Processes

The media of the filter functions both to supply inorganic supplements and as a supplement to the gas stream being dealt with for natural supplements. The assimilated gasses are oxidized by the microorganisms to CO_2. The unstable inorganics are additionally assimilated and oxidized to frame calcium salts. Half-lives of pollutants go from minutes to months. The oxidation of organic matter generates heat (Figure 3) [7, 8].

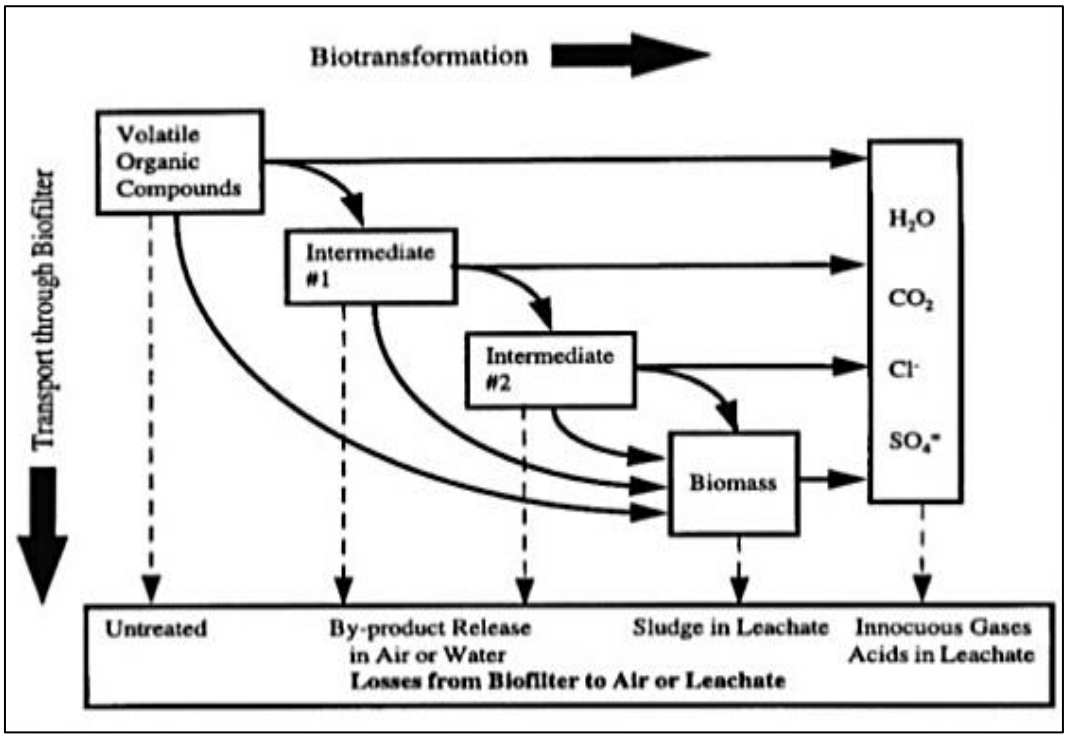

Fig. 3. *Biotransformation and transport process in biofilters.*

Commercial Applications

VOC applications to date have included the following industries:

- Synthetic resins
- Chemical and petrochemical industry
- Waste and wastewater treatment
- Pharmaceutical industry
- Paint and ink
- Oil and gas industry
- Soil and Ground water remediation

Odor abatement applications to date have included the following industries.

- Agricultural and meat processing
- Tobacco, cocoa and sugar industry
- Flavor and fragrance
- Gelatin and glue plants
- Slaughter houses
- Sewage treatment
- Rendering [9]

Advantages of Biofiltration

Biofiltration has many advantages over traditional VOCs and HAP destruction methods.

- Low annual operating cost – There are only two major power consumers in a biofiltration system: a recirculation pump for humidification and a fan to pull the gas stream through the equipment.
- VOCs and HAPs are oxidized at ambient temperatures – The low temperature oxidation eliminates the high costs associated with combustion.
- Environmentally friendly – Zero NOx emissions, zero SOx emissions and substantially lower carbon dioxide emissions.
- Low pressure drop – Much lower pressure drop than catalytic or regenerative thermal oxidizers resulting in fan power consumption savings.
- Proven effective technology – Biofiltration systems are in place with historical operating experience demonstrating regulatory compliance.
- Intrinsically safe – The low temperature oxidation and high moisture content eliminate the fears associated with combustion.

- Low maintenance – Very few moving parts result in lower maintenance cost [10].

Disadvantages of Biofiltration

- Acclimation periods for the microbial population may take weeks or even months, especially for VOC treatment.
- Sources with emissions that fluctuate severely or produce large spikes can be detrimental to the of a biofilter's microbial population and overall performance.
- Contaminant sources with high chemical emissions would require large biofilter units or open areas to install a biofiltration system.
- Biofiltration cannot successfully treat some organic compounds, which have low adsorption or degradation rates. This is especially true for chlorinated VOCs [10].

CONCLUSION

Biofiltration gives a financially savvy, monetary way to deal with contamination decrease with fundamentally brings down cost per ton treated than elective air pollution control (APC) innovations. Biofiltration gives many points of interest to other APC innovations. Beside the immediate cost to the client, there is a middle national cost in regular assets including, however not restricted to, the cost of boring for flammable gas, creating power (coal), and the related contamination that these exercises produce. Biofiltration keeps away from these cost with a characteristic arrangement. Weight drop through the framework is lower than reactant or regenerative warm oxidation which saves money on power utilization. Oxidation happens at surrounding temperatures with the utilization of normally happening microbes taking out the requirement for flammable gas utilization in cremation. Since no supplementary fuel is required, the biofilter creates considerably less CO_2 diminishing ozone depleting substance discharges from the APC hardware. Biofiltration is a damaging innovation, oxidizing the mixes to CO_2 and H_2O disposing of the recovery cost of initiated carbon and the water treatment cost of cleaning. The Biofilter does not make auxiliary poisons, for example, NOx mixes or CO. Biofiltration was chosen to accomplish both high VOC expulsions (90%+) and receive extra monetary rewards from the innovation.

Biofiltration plays very important role in control of air pollution. Biofilter, like all systems follows laws of conservation and mass balance. Biofilter is successful only when microbial ecosystem is healthy and vigorous. The design of biofilter system requires a detailed understanding of site, conditions, site limitations, system components and costs.

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