HAND-OUT

CONTROLLING ODOURS FROM MUNICIPAL AND INDUSTRIAL WASTEWATER PLANTS

DESIGN AND OPERATION OF BIOFILTERS

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1.0 BACKGROUND

A. Firstly, the term biofilters can mean different things to different people. Some refer to biofilters as a method of processing odourous gases while others consider the name to be synonymous with trickling filters. Since this is a seminar on odour control the term biofilter in this paper refers to a process to treat municipal odours.

B. Biofilter design is somewhat more of an art than a science. While there are some basic parameters that should be adhered to, some aspects of biofilter design have a debatable relevance. The best biofilter design is simply the one that works for your application. The comments given in this paper describe what Dayton & Knight Ltd. has found to work for odours from municipal wastewater treatment systems in British Columbia.

C. The paper considers 3 main sections regarding biofilters:

   i) introduction
   ii) design criteria
   iii) maintenance design features and maintenance procedures

2.0 INTRODUCTION

Biofilters have been in use worldwide for over 25 years and many of the earlier biofilter applications occurred in New Zealand. Biofilters have been in use in Europe for about 15 years and in North America for about 10 years.

The process involves blowing foul air through a biological filter. When they are properly designed, constructed, and operated, biofilters are a low maintenance, cost effective method for effectively removing water soluble odorous compounds from high volume air streams with relatively low contaminant levels.

The foul air is forced through a bed of organic matter which consumes contaminants, through the process of sorption, followed by biological and chemical oxidation. The sorption phase (which includes both adsorption and absorption) converts the treatable compounds. This is understood to occur prior to the commencement of any biological or chemical oxidation. As the foul air stream is discharged into the filter media, the air encounters microorganisms with nutrients and sufficient moisture to allow microbiological growth (biomass) to occur. The biomass grows by feeding on carbon in the media and nutrients in the foul air. There are many symbiotic relationships in the micro-organism community. Over time the ability of the media to provide the necessary carbon diminishes and the media eventually requires replacement.

Other than electrical energy to discharge the foul air into the media and possibly drainage pumping to discharge condensate, the biofilter uses no other mechanical parts or chemicals. It has been used in numerous locations worldwide to effectively remove odorous compounds at wastewater treatment facilities.

3.0 DESIGN CRITERIA

3.1 General

As previously mentioned, there are varied opinions on the ingredients of a biofilter, and in some cases the make-up of the media is considered as proprietary. Specification data in those cases is often difficult to obtain.

Essential to all successful biofilters is a media which allows the passage of air at a reasonable headloss. The selection of media involves a balance between porosity, substrate ability to hold moisture, and an ability to provide carbon for the biomass substrate.

3.2 Media Types

The basic requirements for biofilter media are materials which have sufficient porosity and near uniform particle size. Particles should have relatively large surface areas and significant pH buffering capacities together with the ability to support a large population of microflora.

Soil, peat and/or compost are some of the essential ingredients and a carbon containing bulking agent is the other key material. Wood chips is a typical suitable ingredient and the material should be hemlock, balsam or fir. Mixtures of these are sometimes produced and this is marketed as "Hembalf". Cedar (both yellow and red) should not be used as these will significantly increase the acid content of the biofilter and acidic gases may result. Bark is considered by some to be an unsuitable product while others recommend its use. Our experience has been that in relatively moist climates, that bark continues to break down into smaller particles and eventually becomes like a compost product and blinds off (plugs) the biofilter.

The use of shale, lava rock or low iron volcanic scortia is promoted by some as being a suitable ingredient. This product is used as a cover at Ladysmith where a small biofilter exists that we designed. We first saw lava rock as a cover being used in New Zealand. Where lava rock is provided, a carbon layer source is also required (soil, compost).

Although compost is used in many biofilters, it will continue to break down into smaller particles and can increase the possibility of plugging or blinding of the biofilter. Compost was used in many of the earlier versions of biofilters.

As an alternative to bark, the bulking agent in a biofilter at a Wastewater Treatment Centre in Oregon uses chopped hemlock tree roots in a 50 mm long to 200 mm long size. That biofilter has been in operation for 4 years and continues to operate successfully. About one third of the media was replaced after about 1-1/2 years of operation as the centre of the biofilter had settled and additional media was needed.

There are also various specialty media products which are marketed as having superior performance. One example uses a combination of coarse hard and soft bark nuggets which reportedly have been preshrunk. Another engineered media is referred to as an “Activated Soil”. Specific details as to what this consists of are difficult to obtain. While these products are likely suitable, the need to purchase an engineered media is debatable, given the many successful applications that use naturally occurring materials. Engineered media are also generally relatively costly (up to 5 times more has been quoted).

3.3 Media Depth

The media depth requires to be of sufficient height to allow adequate contact time between the foul air and the biofilter media. A minimum depth of about 1 metre is typically necessary to achieve this. The provision of an adequate bed depth is particularly important if the media selected has a relatively high degree of bulking agent.

3.4 Moisture and Drainage

Moisture content within a biofilter is a key component to the successful operation of the system. Typical moisture contents are between 30 – 70%. Although rain can provide much of the required moisture, it is common to add water sprays to ensure the biofilter does not dry out. If this were to occur, the biological activity in the biofilter would decrease and if left uncontrolled, would eventually cease to operate and the odorous gases would pass untreated through the biofilter.

For a properly functioning biofilter drainage is important and the concentrate must be adequately drained to a gravity sewer/forcemain system.

3.5 Geotextile Layer

This is an optional feature but one which we have found helps to provide protection to the drainage piping and surrounding granular layer during placement and replacement of the media. It is typically installed between the biofilter media and the granular layer of bedding that surrounds the foul air distribution piping. A typical geotextile type is two layers of Tensar SS-1. On no account should a geotextile cloth be used as the biofilter will blind off at the underside of the cloth layer.

3.6 Foul Air Piping

This is a manifold system that distributes the foul air through the media. 12 mm diameter holes are typically drilled at the 3, 6, and 9 o’clock positions of the diffuser piping to facilitate drainage and at the same time to allow the foul air to be distributed up evenly through the media. Some biofilters use Big ‘O’ type of pipe with slots in the diffuser piping. We consider there is a greater tendency for these slots to plug-up than formed diffuser holes, and our preference is for the latter.

3.7 Granular Layer

A granular layer typically surrounds the foul air piping. This layer provides structural support to the foul air piping as well a relatively porous media for the foul air to pass up to the biological layer of the biofilter media.

As a minimum, the granular layer typically consists of drain rock. On larger applications, the economy of scale can justify the use of a multiple layer granular section such as drain rock overlain with a pea gravel layer. Other applications use an open plenum under the media with the media supported on either fibreglass grating or cattle grids.

3.8 pH

To maintain odour treatment, it is important that the pH in the biofilter be maintained at or near neutral. The treatment of hydrogen sulphide in biofilters will produce sulfuric acid. Typically, there will be enough buffering capacity in the foul air stream to prevent a reduction in pH and pH adjustment should not be necessary.

Use of oyster shells is sometimes used as a carbonate source for buffer protection. There is no known proof that the oyster shells have any practical effect.

3.9 Temperature

In the Lower Mainland, ambient air temperatures are typically adequate. Although biological activity increases by a factor of approximately 2 for each 10^{o}C rise in temperature up to an optimum of approximately 37^{o}C, heating of the inlet air is generally difficult to justify. In relatively cold climates, steam injection is sometimes used.

3.10 Residence Time

Typical values are somewhere between 30 – 60 seconds and in some cases up to 120 seconds. The longer times are sometimes used where particularly odorous gases exist or where conditions are unpredictable.

For typical treatment needs, the lower end of the range is a requirement to ensure adequate contact time exists between the foul air and the media. The upper end of the range defines the period after which little additional benefit is generally achieved (unless the gases are particularly odorous).

3.11 Loading Rate

Typical superficial values are 50 – 100 m^3/m^2/hr.

3.12 Headloss

Headloss through a biofilter is typically in the 100 mm to 150 mm W.C. range. The Oregon example previously referenced has a headloss of only 50 mm W.C. This is lower than average. When headlosses climb above 200 mm W.C. this is often indicative of a biofilter whose surface has blinded off.

4.0 MAINTENANCE DESIGN FEATURES AND MAINTENANCE PROCEDURES

4.1 Moisture and Covers

Moisture is essential for biological activity to occur in a biofilter. An overly dry biofilter will not function properly nor will an overly wet one. Although rainwater can assist in providing this moisture, there are periods during the year, even in the Lower Mainland when the moisture content in a biofilter, if left unattended, can fall below 30%. Below that the biofilter will become ineffective if left in that condition. This can be prevented by installing a Rainbird type of automatic sprinkler system which activates through moisture sensors. It has been our experience that these sensors are not always reliable and a more foolproof system is to install a timer arrangement. Moisture should be checked weekly and at least 600 mm down into the media (media is typically warmer and drier inside the media than on the surface).

Biological activity within the media will also be severely impacted if the media becomes overly wet (greater than 70%). This can be addressed by covering the biofilter with an umbrella type of light roof (with open sides).

4.2 Smoke Testing and Preventing Short Circuiting

This testing method is extremely useful in detecting whether or not short circuiting is occurring within a biofilter. Immediately following construction smoke testing should be used to check for possible short circuiting and plugging of diffuser holes. After commissioning, monthly testing as a minimum is recommended. This inspection also helps detect any leaks which may have developed in the foul air ducting.

Many biofilters are placed within containers. As the biofilter media shrinks, (a natural occurrence), a gap will typically occur around the perimeter and short circuiting can occur. We have found that a way to overcome this is to bolt a continuous 75 mm x 75 mm angle (fibreglass) about 300 mm below the surface of the media.

If space on site is not a premium, short circuiting can be prevented by extending the biofilter media over the walls or edges of the biofilter or the walls or edges can be located a metre or so beyond the end of the diffuser piping.

4.3 Fertilizing

During start-up, fertilizing will help accelerate the biological process in the biofilter. Should a measurable reduction in pH occur, weekly tests should be carried until stability occurs. If the pH drops below 6.5, lime should be added. Similarly if the ambient temperature drops below $0^{o}C$ for over a week, the addition of some fertilizer will help increase biological activity within the biofilter media.

4.4 Rototillings

This practice is sometimes carried out in an attempt to “fluff-up” the media and improve the pore spaces. In our opinion, this method is generally counter productive as the tendency is for the rototilling to increase the shredding of the media which in turn helps compact the material and increases the need to rototill the media again on an increasing frequency basis.

4.5 Weeding

Weeds often grow on the surface of a biofilter. If left unchecked the weeds will eventually blanket off the top of the media and will severely affect the biofilter performance. Ventilation fans used for discharging the foul air are generally of the centrifugal type which can operate against a closed valve. A weed covered biofilter has a similar effect.

In removing the weeds, it is important that the media surface is not walked on. This should be prevented by constructing a moveable frame over the top of the biofilter to support operations personnel while they remove any weeds. Walking over a biofilter is counter productive to its operation, as such activities will compact the media surface.

An alternative biofilter cover approach that is sometimes used in New Zealand is to cover the top surface of the biofilter with grass. The theory is that the grass roots help absorb excess moisture and encourage breaking up of the top layer. Although successful biofilters exist in New Zealand using this design concept, we consider there is the potential for the grass cover to become so dense that it could blanket off the top of the biofilter. Our preference is not to allow the growth of grass on top of the media.

4.6 At Grade vs. Below Grade Biofilters

Either option can be used provided adequate drainage is provided. This is particularly important for the below grade design. An advantage of the below grade biofilter is that it has a relatively low visual impact.

4.7 Media Replacement

Being an active biological process, biofilter media will eventually become ineffective, will break down into smaller particles, and will require replacement. The time for this to occur varies but a typical period is 3 to 5 years.

SUMMARY

In summary, although the design and operation of biofilters can involve a variety of opinions, some basic parameters should be followed. In designing a biofilter it is important to retain a Consultant with experience in this area and to adopt a design with a proven track record.